EXAMINATION OF CHILDREN
BY
CLINICAL AND LABORATORY METHODS

BY
ABRAHAM LEVINSON, B.S., M.D.

ILLUSTRATED

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TO MY STUDENTS

MY BEST TEACHERS

INTRODUCTION

The human body is a biochemical being. Like all living beings, it is not at a standstill; it composes and decomposes, it secretes and excretes, and as soon as it ceases to undergo changes, it is dead. In spite of the constant changes, however, the body retains a certain equilibrium, within wide limits, during health, and a disturbance of the equilibrium outside the normal limits invariably means disease.

Often disease may be detected by purely clinical methods such as inspection, palpation, percussion and auscultation. A diagnosis may sometimes be reached by these simple methods much easier than by the most complicated laboratory methods. At times, however, ordinary clinical methods do not suffice and one has to resort to laboratory procedures. It should be the aim of every clinician to develop his sense of sight, hearing and touch in order to utilize them for diagnostic purposes. In addition to the purely clinical methods, one should, however, be familiar with the most practical laboratory tests.

Of late, a great number of tests have been proposed for various diseases Some of them are easily applicable, others are not. All tests, however, have to be interpreted correctly; otherwise they are not only useless, but may even be misleading. Unfortunately, some physicians, recent graduates as well as old practitioners, are not familiar with the interpretation of tests. Laboratory workers are constantly being asked by physicians for "complete blood" or "complete laboratory work", and on furnishing the complete report they are again asked to interpret their results. On the other hand, there is another extreme toward which some physicians, especially young graduates, are tending, namely, to place laboratory tests above all clinical signs and symptoms. The danger of such an attitude becomes evident when a special laboratory test, such as throat culture, proves negative. We all know how frequently it happens that a culture in a case of diphtheria, in spite of all clinical signs pointing to a diphtheria, is negative.

What is true of the interpretation of laboratory work in general is doubly true of laboratory work in pediatrics, for the result of a test that indicates pathology in the adult may be of no significance in the child. Such, for instance, is the case with leucocytosis and lymphocytosis which is a part of the normal blood picture in children.

Laboratory procedures in children present one more difficulty in that special methods are often required to obtain a specimen from the patient. Such is the case with blood, where the jugular vein or longitudinal sinus have to be resorted to in order to get sufficient material for a Wassermann test or for blood chemistry. Such is the case in cerebrospinal fluid, where ventricular or cistern punctures have to be employed in order to obtain fluid or to inject serum. The same is even true with urine where special methods have to be resorted to in order to collect a specimen for examination.

In view of the above considerations, it has occurred to me that a course discussing both the clinical value and limitations of laboratory tests in their relation to pediatrics would meet a vital need in the curriculum of the medical school. Through the kind permission of Dr. I. A. Abt I was fortunate enough to be able to present such a course to several classes during the last few years at the Northwestern University Medical School.

The course, as I give it, deals with the interpretation of clinical and laboratory tests as applied to pediatric practice. In studying case history the importance of the various questions in relation to diagnosis is considered. In studying the physical examination, the importance of various procedures is discussed in connection with diagnosis. Stress is laid on simple procedures, such as facial expression of the child, posture and state of nutrition. The student is also instructed in the proper position of the patient during examination. In studying the blood, the value and limitations of leucocytosis, of relative lymphocytosis, of blood sugar, nonprotein nitrogen, creatinine and urea, of alkali reserve, Wassermann, blood culture and blood grouping are discussed. In studying the urine, the value and limitations of albuminuria, reduction tests, cells, casts, quantitative chlorides, total nitrogen, urea, uric acid, ammonia and kidney function tests, are discussed. Cerebrospinal fluid, milk, stool, and pleural exudate, are studied in the same way. The interpretation of skin tests and of x-ray are also discussed.

A case is presented at every lecture and the tests previously done are interpreted and compared with the clinical findings. Occasionally, difficulty arises as to what value should be attached to certain laboratory results. It is a well-known fact that various workers attach different values to certain tests. Such, for instance, is the case with indican and creatinine in urine, and the fragility of corpuscles in the blood. In such cases I make it a point to tell the students that there is a diversity of opinion as to the value of the test, and that it is on the clinical findings, coupled with the laboratory tests, that a decision should be made.

As the course gained popularity it became necessary to give the students some references on the interpretation of the various tests and on methods of obtaining specimens in children. Surprisingly enough, this has become a tremendous task, for the standard textbooks on pediatrics or those on laboratory methods do not always present a discussion of all the methods of obtaining specimens from children or the clinical application of laboratory tests to diseases of children.

It was the necessity of finding a text for my students that called forth an outline which was later published as a series of articles in the *Journal of Laboratory and Clinical Medicine*.

The series of articles consisted of the following:

1. Methods of clinical procedures in infants and children. This included case history, physical examination, removal of blood from the jugular vein and from the longitudinal sinus; spinal, ventricular and cistern puncture; collection of urine; lavage and gavage; skin tests, etc.

The methods were simplified to such an extent that they could be done by every practitioner of medicine.

2. A description of simple laboratory tests that can be carried out in the ordinary laboratory or even office.

3. Above all, a discussion of the interpretation of various clinical laboratory tests as applied to infants and children.

The purpose of the various tests, and the clinical application of the results of the tests to infants and children were discussed. Emphasis was laid on the difference between the normal standards in children and those in adults.

The articles were written, not for the pediatrician or trained laboratory worker, but for the medical student and for the general practitioner. An endeavor has been made throughout to be simple rather than complex, practical rather than theoretical.

A surprisingly large number of requests for reprints of the articles and for a collection of them in book form is responsible for this volume. Most of the articles have been rewritten and the rest have been enlarged. The chapter on Introduction of Fluid into the Child's Body and the one on Intubation and Tracheotomy do not properly belong in a book on clinical and laboratory examinations; however, since these two chapters were included in the original articles that appeared in the journal, and since the subject matter contained in these chapters is very important in pediatric practice, I decided to include them in the present volume.

Four illustrations appearing in this book have been obtained from patients at the University Children's Hospital of Vienna, with the kind permission of Professor Pirquet. Five illustrations have been drawn for me by an artist from patients at the Waisenhouse of the city of Berlin, with the kind permission of Professor Meyer and Dr. Nassau. Two illustrations were borrowed from other texts. All other illustrations have been obtained at the Sarah Morris Hospital for Children.

I hereby take the opportunity of expressing my thanks to Professor Bella Schick of Vienna, Dr. Oscar Schultz and Dr. Robert Arens of Chicago, for their helpful suggestions in the preparation of the book.

A. Levinson.

Chicago, Ill.

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CHAPTER I

CASE HISTORY

In the case of a very small child the history must naturally be obtained from the parent. In the case of an older child the history should be taken both from the parent and the child. Many a child will describe its symptoms more vividly than its mother, who usually adds some flavor to the story. If possible, the mother should be heard in the absence of the child, so that the child will not be influenced by her story. The history should include the following:

1. Onset and course of the present disease.
2. Personal history, including birth, development and previous diseases.
3. Family history, including social history.

I found it best in my practice to inquire first into the history of the patient and later into the history of the family.

Present History.—Careful attention should be paid to the onset of the present disease, whether it was sudden or slow, whether accompanied by fever, chills, convulsions, vomiting, diarrhea, constipation, cough, sneezing or running of the eyes.

The mode of onset may at once throw light on the nature of the disease. It may for instance, help decide between measles and scarlet fever. It is well known that scarlet fever sets in suddenly while measles comes on gradually with coryza, conjunctivitis and cough. Vomiting is a cardinal symptom of scarlet fever, although it may be present in other diseases and occasionally is absent in scarlet fever. Convulsions are rather frequent at the onset of infectious diseases in children, and therefore do not necessarily signify an organic disease of the nervous system. Fever is present in many diseases. The height and the type of fever, however, differ in various diseases. The subsidence of fever also differs in various diseases and may, therefore, also serve as a diagnostic point. Chills are infrequent in children, and when present, should make one suspect malaria. Constipation is no cause for alarm, except when it persists and is accompanied by abdominal pain, when intestinal obstruction should be suspected. Diarrhea is a significant symptom, but it should be ascertained whether or not the patient received any cathartic, as the latter may be the cause of the diarrhea. The number of bowel movements a day and the character of the stool should also be inquired into.

Cough is present in many diseases. The type of cough may, however, throw some light on the diagnosis, such as the barking cough in pseudocroup, the spasmodic cough in pertussis, the dry cough in measles and the ringing cough in enlargement of bronchial glands. A cough that is more frequent at night, and that is followed by vomiting, speaks for whooping cough.

Running of the nose is present in ordinary grippe. Inquiry should, however, be made as to the character of the discharge. A bloody mucous discharge should make one suspect nasal diphtheria, and a culture should be promptly made. A chronic discharge in an infant should make one suspect congenital lues.

Sneezing may be a part of an ordinary cold; when associated with conjunctivitis and cough it should make one suspect measles.

Difficulty in breathing may be the result of laryngeal obstruction by diphtheria, laryngitis or foreign body. It may also be due to asthma, pneumonia or carditis.

Hoarseness often accompanies an ordinary attack of grippe, still it should always be associated in the physician's mind with the possibility of laryngeal diphtheria, especially when the child is acutely ill. Pain is an important symptom but may be misleading. Children often have referred pain, especially over the abdomen, so that tonsillitis or pneumonia may have abdominal pain as their first manifestation. On the other hand, pain should not be made light of. Many a child suffering with appendicitis has lost its life because of the diagnosis of mere "digestion pains." Pain in any joint should make one suspect acute or chronic rheumatism. Pain in the ears may be referred from the throat. It may, however, be the result of an actual inflammation of the drum membrane.

In addition to the history of the onset, inquiry should be made as to the course of the present disease, whether the condition of patient improved or was aggravated, whether there were any special complications, whether the child received antitoxin and how much. It may be best to let the mother describe the disease in her own words, as in this way some light may be thrown on the history of the disease which could not be brought out by questions.

Personal History.—In addition to the name, age and sex the personal history should include questions regarding the birth, method of feeding, development and previous diseases.

Birth.—Whether the patient was born at full term or was premature; whether the birth was natural or instrumental; whether the labor was precipitate or prolonged. Prematurity may explain congenital weakness or rickets. Modern research has shown that instrumental or prolonged labor may be responsible for brain hemorrhage in the newly born, which may later manifest itself in a spastic paralysis.

Method of Feeding.—Whether the child is or was breast-fed and for how long a period. If artificially fed, inquiry should be made as to the kind of food and the frequency of feeding, also as to whether the child was or is

getting orange juice or other fruit juices. The method of feeding may explain malnutrition, scurvy, tetany, and intestinal disturbances.

Development.—Inquiry should be made as to gain or loss in weight from birth to the onset of the disease. This may give the physician an idea whether the child was normal up to the onset of the disease or was chronically ill; as to the time the child first sat up, walked, and talked, an important consideration in the diagnosis of rickets, idiocy, and congenital syphilis. Inquiry should also be made as to the time of the eruption of the first tooth and of the subsequent teeth. The latter, however, is not nearly so important in diagnosis as it was formerly thought to be; while many rachitic children erupt their teeth late, there are many healthy children in whom the first tooth is not erupted before 12 or 15 months of age. On the other hand, some congenitally weak children erupt their teeth early.

Previous Diseases.—The history of the following diseases is of the utmost importance:

1. *Intestinal Disturbances,* which may account for chronic digestive disturbances and malnutrition.

2. *Rickets,* which may be responsible for deformities of the chest or for delayed development.

3. *Tetany,* which may be responsible for convulsions or other neurotic manifestations.

4. *Scarlet Fever,* because of the fact that one attack usually confers immunity, and because of the frequency of nephritis, otitis and adenitis following the disease.

5. *Measles,* which often predisposes the patient to bronchopneumonia and otitis media.

6. *Pertussis,* which is nearly always followed by chronic bronchitis and is often followed by pneumonia and encephalitis. It also predisposes the patient to tuberculosis of the respiratory tract.

7. *Diphtheria,* which may be responsible for myocarditis, stenosis of the larynx and paralysis of various parts of the body.

8. *Tonsillitis* which may be responsible for chorea and carditis. An inquiry should be made as to the presence of the so-called "growing pains," which are often nothing more or less than an acute or subacute articular rheumatism.

9. *Pneumonia,* which makes a second attack more liable, and which is often followed by complications, especially empyema.

10. *Meningitis and encephalitis* which may be responsible for many nervous disturbances, such as convulsions or epilepsy.

11. *Trauma,* which may be responsible for a multitude of affections.

12. *Surgical diseases,* which may cause adhesions or leave other sequela.

One should bear in mind that there is hardly a disease which does not leave its trace upon the child's body or mind.

In addition to previous diseases, inquiry should be made as to whether or not the child has been vaccinated. This is especially important during an epidemic of smallpox.

Family History.—This should consist of questions as to the health of the parents with special reference to the health of the mother during pregnancy, to miscarriages preceding or following the birth of the patient; as to the incidence of diseases in family with special reference to tuberculosis, syphilis, rheumatism, carditis, alcoholism, epilepsy, and idiocy. All of the above questions may have a direct or indirect bearing on the present condition of the patient. The state of health of the parents is naturally important, as diseased parents may transmit their diseases to their offspring, or at least cause a lowered resistance in the child. The health of the mother during pregnancy is important as trauma or convulsions on the part of the mother may cause premature birth or idiocy. Miscarriages preceding the birth of the patient should make one suspect syphilis. The history of the other children in the family may throw light on the status of the patient. One may, for instance, infer by a history of a recent exanthem in one of the other children in the family that the patient's rash may be the same exanthem. The same inference may be drawn as regards tuberculosis or syphilis.

The social condition of the patient should also be inquired into. The method of living may throw light on the causation of the disease and the knowledge of this may help in the treatment, especially in deciding whether the patient should be kept at home or sent to a hospital.

CHAPTER II

PHYSICAL EXAMINATION

Good light is essential for examination. The room in which the child is examined should be warm. A thorough examination of the entire body should be made, even if the complaint is limited to a certain part of the body; as at times, the examination of the part of which no complaint is made furnishes more information than the examination of the affected part. In order to make a thorough examination the patient should be completely undressed. The part that is not examined should, however, be covered.

It is best to have some system of procedure in examination. I have found the following to be most serviceable: (1) General inspection of body; (2) palpation of various portions of body; (3) detailed examination of chest, abdomen, and of nervous system. The examination of the nose, ears, and mouth and the measurement of temperature should be done last whenever possible; if done first, it may estrange the child from the physician.

The examination of a child cannot be completed in a hurry. "He who runs" cannot learn everything about a child. The examination should be done slowly, with a great deal of deliberation, so as to notice all details and to win the child's confidence; however, if the child is of a fighting disposition, no time should be lost on argument, but detailed examination should be done, nevertheless.

Position of Infant During Examination.—The examination of infants is often beset with difficulties. Some physicians prefer to examine the infant in the recumbent posture on a table; others prefer to have the infant in recumbent posture on the mother's lap; and still others prefer to have the infant in a sitting position on a table or on the mother's lap. No rule can be given for the position of the child; it depends upon the age of the infant, the ability of the mother or nurse to assist the examiner, and above all, the part of the body to be examined.

The various parts of the body require different positions on the part of the child. The anterior portion of an infant's chest may be examined:

(1) By laying the infant on the table and having the mother or nurse stand at the edge of the table holding the baby's head and arms (Fig. 1).

(2) By having the mother or nurse sit on an ordinary kitchen chair and hold the baby's legs tightly in her lap, causing the baby's occiput to lean against her chest, and restraining the baby's head with her left hand and his arms with her right hand.

(3) By sitting the baby on a table, if the infant can sit up, and having the nurse stand behind the child to support his back with her body and hold his arms and legs with her hands (Fig. 2).

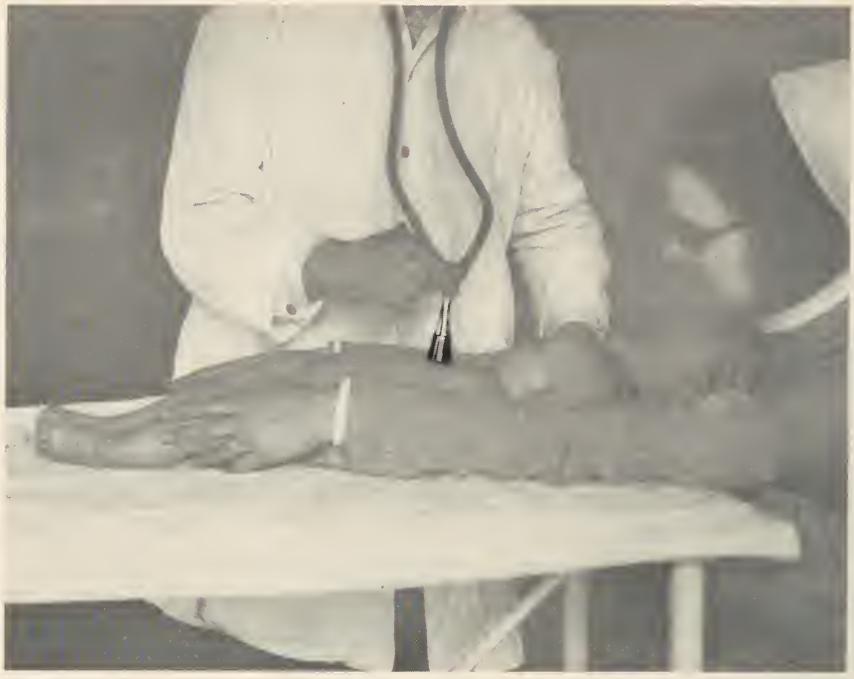

Fig. 1.—Examination of anterior portion of infant's chest with patient in the recumbent posture.

Fig. 2.—Examination of chest with patient in sitting position.

The posterior portion of an infant's chest is best examined by placing the infant's head on the mother's or nurse's shoulder and having her support his head with one hand and hold his arms to the side of his body with the other hand (Fig. 3). If the infant can hold his head up, he may be examined by sitting him up on a table and have his mother or nurse stand in front of him to hold his hands and to attract his attention.

The mouth and throat of an infant are best examined by having the mother or nurse hold his head firmly with one hand and his arms with the other hand, the head being rested on the mother's chest (Fig. 4). The ears

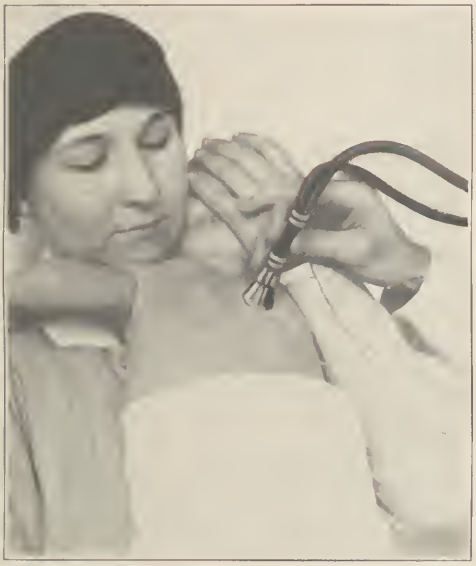

Fig. 3.—Method of holding infant for examination of posterior portion of chest.

Fig. 4.—Method of examination of infant's throat.

are best examined by placing the infant opposite the light in such a way that one cheek will be leaning on the mother's chest.

Development and Nourishment.—The general appearance of the patient will show at a glance whether he is well-nourished, well-developed, overdeveloped or underdeveloped (Figs. 5 and 6). More accurate information can be obtained by weighing and measuring the patient. In infants, the weight is one of the best indications as to whether or not the feeding agrees with the patient. In interpreting the weight, however, the relation of the weight to the height, the birth weight and the racial characteristics should be taken into account. It is natural that what is good weight and measure at three months for a prematurely born infant would be poor for a full-term baby. The accompanying height-weight table of Dr. Wood gives the approximate weight in relation to the child's height. Pirquet utilizes the sitting height, namely, the length between the head and buttocks, as an index for the amount of food a child is to get and also as an index of the state of nutrition.

TABLE OF HEIGHTS AND WEIGHTS OF CHILDREN

AGE	BOYS		GIRLS		AGE	BOYS		GIRLS	
	HEIGHT	WEIGHT	HEIGHT	WEIGHT		HEIGHT	WEIGHT	HEIGHT	WEIGHT
	Inches	Pounds	Inches	Pounds		Inches	Pounds	Inches	Pounds
Birth	20.6	7.6	20.5	7.16	33 mos.	36⅛	30⅝	35⅝	29⅛
3 mos.	23½	13	....	....	34 mos.	36½	31⅛	36½	30⅛
6 mos.	26½	18[3]	25⅞	16¾[3]	35 mos.	36¾	31⅞	36½	30¼
7 mos.	27¼	19⅛[3]	26½	17⅜[3]	36 mos.	37⅛	32¼	36¾	30½
8 mos.	27⅝	19¾[3]	27	18¼[3]	37 mos.	37⅜	32¼	36¾	30¾
9 mos.	28⅛	20⅜[3]	27⅝	19⅛[3]	38 mos.	37½	32⅜	37	31
10 mos.	28½	20⅞[3]	27⅞	19½[3]	39 mos.	37⅞	33⅛	37¼	31⅝
11 mos.	29	21⅜[3]	28⅜	20⅛[3]	40 mos.	38½	33½	37½	32
12 mos.	29⅜	21⅞[3]	28⅞	20¾[3]	41 mos.	38⅝	33⅝	37¾	32¼
13 mos.	29⅞	22⅞[3]	29⅜	21[3]	42 mos.	38⅞	33¾	38	32½
14 mos.	30¼	23[3]	29½	21⅝[3]	43 mos.	38¾	33¾	38¼	32¾
15 mos.	30¾	23⅝[3]	30⅛	21⅞[3]	44 mos.	38⅞	34¼	38½	33
16 mos.	31⅛	24⅛[3]	30½	22⅞[3]	45 mos.	39	34½	38½	33¼
17 mos.	31⅜	24½[3]	30¾	22⅞[3]	46 mos.	39	34¾	38¾	33½
18 mos.	31¾	24⅝[3]	31⅛	23⅜[3]	47 mos.	39¼	35¾	38⅞	33½
19 mos.	32¼	25½[3]	31½	23¾[3]	48 mos.	39½	35⅞	39	33¾
20 mos.	32⅝	25¾[3]	32	24⅛[3]	5 yrs.	41.6	41.1	41.3	39.7
21 mos.	32⅞	25¾[3]	32¼	24¾[3]	6 yrs.	43.8	45.2	43.4	43.3
22 mos.	33¼	26⅞[3]	32⅝	25¼[3]	7 yrs.	45.7	49.1	45.5	47.5
23 mos.	33⅝	27[3]	32⅞	25⅝[3]	8 yrs.	47.8	53.9	47.6	52.0
24 mos.	33¾	27⅛[3]	33⅜	26⅜[3]	9 yrs.	49.7	59.2	49.4	57.1
25 mos.	34	27⅞	33¾	26⅞	10 yrs.	51.7	65.3	51.3	62.8
26 mos.	34⅛	28¼	33⅞	27¼	11 yrs.	53.3	70.2	53.4	68.3
27 mos.	34¾	29	33⅞	27¼	12 yrs.	55.1	76.9	55.9	78.7
28 mos.	35⅛	29⅛	34⅝	27¾	13 yrs.	57.2	84.8	58.2	88.4
29 mos.	35⅜	29¼	34¾	27¾	14 yrs.	59.9	94.9	59.9	98.4
30 mos.	35⅜	29½	34⅞	28¼	15 yrs.	62.3	107.1	61.1	106.1
31 mos.	35½	30½	35⅛	28¾	16 yrs.	65.0	121.0	61.6	112.0
32 mos.	36	30⅝	35⅜	29					

FACIAL EXPRESSION.—A normal child is happy and lively; an idiotic child stares; a child with adenoids has an "expressionless" expression; an acutely ill child, especially one suffering from pneumonia, has a painful expression; a child with diphtheria has a sleepy appearance; one with typhoid, an apathetic expression; a child with pyelitis is sad, and the corners of his lips are drawn downwards and outwards; a child with a chronic disease has a melancholic expression; a child with toxemia has a tired-out, semicomatose expression; a moribund child is comatose.

In connection with the facial expression, the cry of the child should be considered. A cry of a healthy child is quite different from the sharp cry of a child in pain. A hoarse cry should make one suspect laryngeal diphtheria. The whining of a child bespeaks continuous pain.

POSTURE.—A child suffering from pneumonia or pleurisy usually lies on the affected side; one suffering from peritonitis lies on his back with his legs drawn up; a child with meningitis usually lies on one side or on his back with the legs drawn up and the head retracted, the retraction, at times, being very pronounced. A patient with cardiac decompensation has to be propped up on pillows, and in the advanced stages assumes the orthopneic position (Fig. 7) and still later lies on the right or left side in a crumpled position (Fig. 8). A patient suffering from asthma sits up during the attack. A patient with spasmophilia has a carpopedal spasm during an attack. A

patient with laryngeal diphtheria changes his position every few seconds, lying down, sitting up, and standing up, struggling for air. The sleeping posture is also important. A child suffering from adenoids digs his face into the pillow; a rickety child moves from place to place in his sleep, and

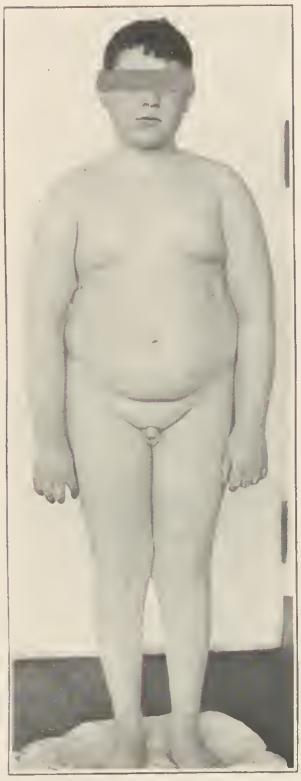

Fig. 5.—Boy of ten presenting Fröhlich's syndrome.

Fig. 6.—General appearance of extremely emaciated infant, one year of age.

rubs the back of his head against the pillow, a factor in the production of alopecia in infants.

Skin.—Observations should be made as to the color of the skin, its elasticity, the presence of rashes, hemorrhage, swelling and scars. The normal skin in the newborn is red and greasy. After a week or ten days, the scales come off and the skin gradually assumes a lighter color and becomes

smooth. During the first few days of life, the baby is frequently jaundiced, but unless the jaundice is very deep, and the child is toxic, it may be of the physiologic type. Jaundice is best recognized by the discoloration of the sclera. In older children jaundice is always pathologic. Anemia is frequent in children, and may be detected by mere inspection. To determine the cause and the degree of anemia, however, finer methods are required.

Eczema is rather frequent in the first year of life. It constitutes the so-called exudative diathesis. It is present in fat, flabby babies, and also in very thin babies. The eczema of infancy varies from a mere scaly area to a

Fig. 7.—Orthopnea in patient with decompensated heart.

Fig. 8.—Characteristic posture of patient with decompensated heart.

weeping generalized eruption, and can easily be recognized. In older children, eczema is often present behind the ears, otherwise it is infrequent.

Impetigo is present all through childhood, especially in the newborn, in whom the eruption resembles pemphigus. Pemphigus, however, is rare. Bullous eruptions are frequent in syphilis. Urticaria follows injection of serum and the ingestion of foreign proteins. Urticaria is recognized by the presence of wheals. The cause, however, must be determined by the history.

Tuberculides (Fig. 9) accompany active tuberculosis. Tuberculides must be differentiated from lichen urticatus and from syphilitic papules. Exanthemata are diagnosed not only by the character of the rash, but by the history of onset, and the other constitutional symptoms. Particular attention

Fig. 9.—Tuberculides.

Fig. 10.—Wrinkling of skin in infant suffering from congenital syphilis.

should be paid to scaling, as this may be the first indication of the presence of scarlet fever. Scaling, however, is present also in other infections, and may also be due to the application of medicaments. Large scales are present in ichthyosis, Ritter's and Leiner's disease. Hemorrhage is present in infantile scurvy, hemophilia, purpura, and various acute infectious diseases. It may also be due to trauma. Edema, when present, should be observed as to its location and as to whether it is generalized, as in cardiac decompensation, or localized as in some forms of nephritis and as is found in areas adjacent to localized inflammations. Localized swelling may be due to en-

Fig. 11.—Scars around mouth in case of congenital lues tarda.

larged glands or to new growths. Wrinkling of the skin is present in congenital syphilis and in dehydration due to alimentary disturbances (Fig. 10). Scars may be due to trauma, but may also be due to healed lesions of congenital lues (Fig. 11). Pitting scars usually follow variola and varicella. In the latter, the scars are shiny white. Rheumatic nodules at the metacarpal and elbow joints are often met with in European children and only occasionally in American children.

Lymph Nodes.—In examining the skin, enlargement of lymph nodes should be looked for, especially in the anterior and posterior part of the neck, in the inguinal region, and at the elbow (Fig. 12). Enlargement of the

glands of the neck may be secondary to tonsillitis, to diphtheria, scarlet fever, or retropharyngeal abscess. Acute enlargement of the posterior auricular glands is frequent in German measles. Chronic enlargement of the cervical glands may be due to repeated attacks of tonsillitis, to tuberculosis, to syphilis, to pediculosis capitis, or may be part of a general glandular enlargement as in Hodgkin's disease. Enlargement of the inguinal glands may be due to an acute infection in the inguinal region, or may be due to syphilis, leukemia or Hodgkin's disease. Enlargement of epitrochlear glands should make one suspect syphilis, although it may also be present in nonspecific infections.

Head.—The shape of the head, the presence of dilated veins on the scalp, the patency of the cranial sutures, the size and patency of the fontanelles, the presence of craniotabes, of parietal bosses, the amount, type, and sensitiveness of hair, and various deformities should be sought.

Fig. 12.—Examination for epitrochlear glands.

The shape of the head may disclose the presence of microcephalus, which invariably signifies idiocy; of hydrocephalus (Fig. 13) which is secondary to many organic brain affections, or square head with frontal and parietal prominences which is frequently seen in rickets. Dilated veins on the head signify hydrocephalus.

The cranial sutures are open the first week or two of life. After that if open, they signify prematurity, rickets or syphilis.

A normal fontanelle should be on a level with the rest of the skull. A distended fontanelle usually signifies increased intracranial pressure. A depressed fontanelle often signifies extreme dehydration. The time of closure of the fontanelles is also important. The posterior fontanelle closes normally between one to three months of age and the anterior fontanelle at sixteen to eighteen months of age. A delay in closure signifies rickets, malnutrition, hydrocephalus or myxedema. Premature closure occurs in microcephalus.

Craniotabes frequently accompanies rickets. In palpating for cranio-

tabes, the following method is used: The head of the baby facing the examiner is grasped between both hands, on opposite sides of the skull. If craniotabes is present, the parietal, temporal or occipital portions of the skull will give way under the fingers. Craniotabes present two types: (a) the

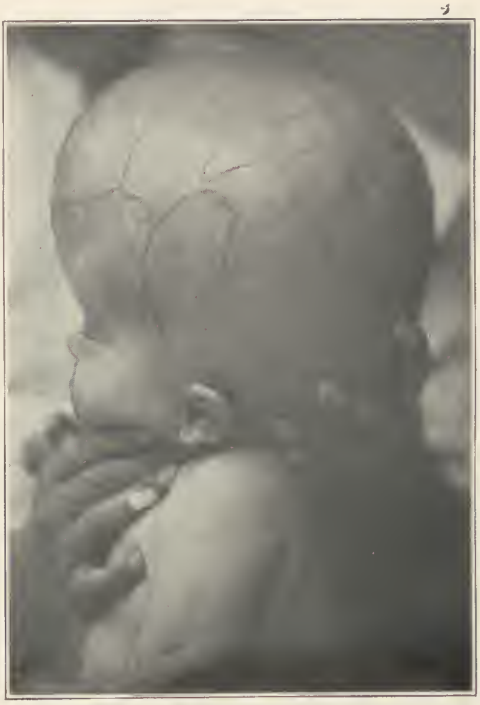

Fig. 13.—Marked hydrocephalus.

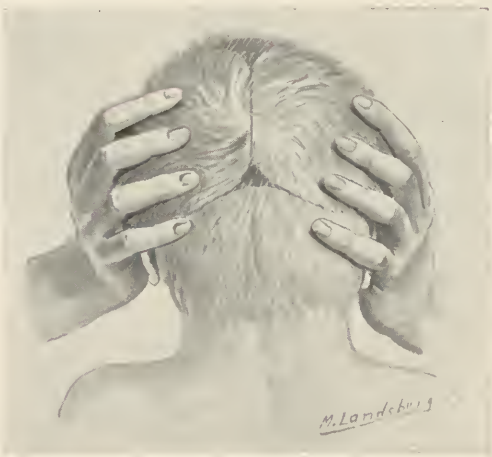

Fig. 14.—Method of examination for craniotabes.

parchment type, when the depressable portion of the bone presents a crackling sensation, resembling parchment or eggshell; (b) the mushy type, when the bone presents a soft, mushy sensation to the touch. Sensitiveness of the scalp in the occipital region is present in erysipelas; coarse hair is present in

cretinism, alopecia is present in syphilis; alopecia of the occipital region is present in rickets.

Contour of Face.—In addition to the facial expression of the child discussed above, attention should be paid to the contour of the face. A cretin, for instance, has a "half moon" face; a child with adenoids has a broad nose, whence the name of "adenoid facies"; a child with congenital lues has a wrinkled face, the so-called "old man's face."

Eyes.—The expression of the eyes, the width of the palpebral fissures, the length of the eyelashes, the size and equality of the pupils, and their reaction to light and accommodation should be observed. Strabismus, nys-

Fig. 15.—Interstitial keratitis and Hutchinson's teeth in case of congenital lues tarda.

tagmus, exophthalmus, corneal ulcer, interstitial keratitis, conjunctivitis, photophobia, ptosis and deformities should be looked for.

The expression of a child's eye will tell at a glance whether the child is active or drowsy, whether he is mentally sound or deficient. An acute observer can often even get an impression of the type of disease by the expression of the eyes.

The width of the palpebral fissure may disclose the presence of a facial paralysis, of an exophthalmus or of mongolian idiocy.

Ptosis is due to paralysis of the third cranial nerve. It is very frequent in encephalitis and may be present in acute anterior polioencephalomyelitis, meningitis, brain tumor and brain hemorrhage. It may also be congenital. Investigation should be made as to the cause.

Long eyelashes are considered by some observers to signify latent tuber-

culosis or phthisical habit in children. Racial characteristics must, however, be taken into consideration. No conclusions should therefore be drawn from the mere length of the eyelashes. Markedly dilated or markedly contracted pupils may be due to intracranial pressure. They may, however, be due to the effects of drugs such as the dilation of the pupils by atropine and the contraction of the pupils by opiates.

Inequality of pupils invariably means organic nervous disturbances. The same is true of alteration in the reaction of the pupils to light and accommodation. Strabismus is present in many infants during the first year of life. The condition usually corrects itself. In older children strabismus is of significance as it requires interference either by refraction or operation.

Nystagmus usually means organic disturbance. It is present in brain tumor and encephalitis.

Exophthalmus due to goiter is seldom seen below the age of ten. Exophthalmus may, however, be present in infants in case of chloroma and in scurvy.

Interstitial keratitis (Fig. 15) may be luetic or tuberculous. Acute conjunctivitis is present in measles and in grippe. It may also be due to other eye infections and to trauma. The etiology of phlyctenular conjunctivitis is still a disputed question. Some claim it to be due to tuberculosis and others consider it of dietetic origin. The weight of evidence, however, is in favor of the tuberculosis theory.

Trachoma is rather infrequent in American children but should be looked for. Complete absence of vision is due to a variety of causes, such as gonorrheal conjunctivitis, brain tumor or amaurotic family idiocy.

Ophthalmoscopic Examination.—Whenever brain tumor or amaurotic family idiocy is suspected, the eyegrounds should be examined. Although an ordinary ophthalmoscope will answer the purpose, an electrically lighted one, such as comes in combination with an otoscope outfit, is more serviceable.

It is preferable to instill a few drops of homatropin in the eye twenty to thirty minutes before the examination. It is, however, often possible to see the eyeground even without previously dilating the pupils. The success of the examination depends on the ability of the nurse to hold the child quiet. Infants must be restrained, older children may cooperate.

The ophthalmoscope is focused on the patient's eye until the red reflex of the eye is obtained. The instrument is then brought closer to the patient's eye, and the vessels, the disc and the macula are observed.

Ears.—The shape of the external ear should be observed. The external meatus should be examined for eczema, also for foreign bodies. Discharge of middle ear and swelling of mastoid should be looked for. Ear drums should be examined by reflected light for redness and bulging. The latter often solves the diagnosis of an obscure fever.

Normally the color of the drum is pearly gray and the ossicles and light reflex can easily be distinguished. Wax obstructing the view of the drum may be removed by a cotton swab, by a small ear catheter, or by syringing the ear with warm water.

Bulging should be considered an indication for paracentesis.

Nose.—The shape of the nose, deformities and nasal obstructions should be noticed. The shape of the nose often serves as a clew in the diagnosis of congenital syphilis; nasal obstruction is frequent in children suffering from adenoids, sinus infection and general grippe. Discharge from the nose may be due to a mere cold, but may be diphtheritic in character. Every mucopurulent discharge from the nose should therefore be considered suspicious of diphtheria and should be cultured for Klebs-Loeffler bacilli. Unilateral bloody nasal discharge should lead one to suspect a foreign body in the nose.

In infants, a chronic discharge from the nose should make one suspect syphilitic snuffles.

Mouth.—The color of the lips should be noted for cyanosis frequent in cardiac insufficiency, anemia frequent in many acute and chronic diseases; for herpes labialis, frequent in pneumonia and meningitis, and for fissures frequent in congenital syphilis.

The gums should be examined for their color, for hemorrhage present in scurvy and in infections of the mouth, and for abscesses.

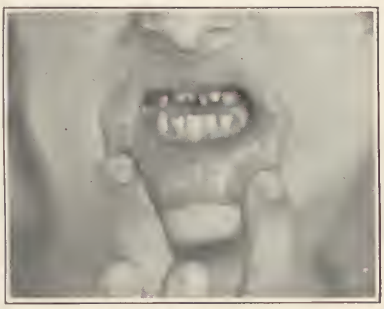

Fig. 16.—Hutchinson's teeth.

The presence or absence of teeth should be observed; delayed dentition, decayed teeth and irregular teeth should be noticed.

Delayed dentition is frequent in rickets, although no diagnosis of rickets should be made on this alone. Decayed teeth are frequently the source of generalized infection and should therefore be noted carefully. Irregular teeth may be present in rickets and a number of other conditions of malnutrition. Hutchinson's teeth are one of the signs of late congenital syphilis.

The mucous membrane of the mouth should be examined for thrush, stomatitis, and enanthemata. It is well known that all exanthemata also have an enanthem. Of special diagnostic importance is the presence of Koplik's spots preceding the exanthem of measles.

The tongue should be examined for color and size. A coated tongue is present in most infectious diseases; strawberry tongue is one of the cardinal symptoms of scarlet fever. A thick protruding tongue is present in myxedema and idiocy. The presence of ulcers, cysts, and scars should also be noted; the latter are often present in epileptic patients.

The hard and soft palate should be noted for enanthemata, for clefts and other deformities.

The tonsils should be noted for their size, for exudates and abscesses. The rest of the pharynx should also be noted for inflammations, exudates and edema. Every suspicious throat necessitates a throat culture, every edematous pharynx should be examined further by palpation with the index finger for the presence of a retropharyngeal abscess.

The larynx cannot be examined by ordinary physical examination, but its condition can be judged by the patient's voice. Any alteration in the voice signifies abnormality. The larynx may also be auscultated. When a stethoscope is applied over the larynx, the normal breath sounds can be heard. In laryngeal diphtheria a deep hoarse tone is transmitted, and in nondiphtheritic laryngitis a high pitched tone is heard, often accompanied by moist râles.

Neck.—The neck should be observed for enlargements of cervical glands, present in acute and chronic infections; for discharging sinuses and scars, for the size of the thyroid, for rigidity present in meningitis and meningism, for head-drop which is present normally in the first two months of life, and later only in pathologic conditions, such as idiocy and anterior poliomyelitis. It should also be examined for anomalies, such as thyroglossal cysts.

Chest.—The shape of the chest should be observed for congenital deformities, and for rosary, Harrison's groove and pigeon breast, present in rickets. The expansion of the chest and the presence of asymmetry, such as bulging or retraction on one side should be noted. Bulging of the precordial region is present in chronic endocarditis and occasionally also in pericarditis. Bulging of the axilla is often present in empyema. Whenever bulging of one side is present the other side may be retracted. Retraction may, however, be present on the affected side, such as happens in chronic adhesive pericarditis.

Distended veins over the chest should also be noted, as their presence indicates an obstruction of the mediastinum by tumor or by tuberculous glands. Unilateral dilatation of veins is even more conclusive of an obstruction within the chest. Retraction of the lower part of the sternum, with a history of an acute onset, should make one suspect advanced laryngeal diphtheria.

Palpation, percussion and auscultation should be carried out the same as in adults. Percussion should be very light. To outline the heart borders, scratching with a coin while the stethoscope is held one-half to one inch away from it is often found more accurate than percussion.

Heart.—Observation should be made as to the visibility of the apex beat, retraction of the chest wall at the apex, and position of the apex beat. The apex beat is usually not visible in infants and children under six or seven years of age unless the child is emaciated. A visible apex beat should therefore make one suspect abnormality. Retraction of the chest wall with each heart beat occurs in adhesive pericarditis. Abnormal position of the apex beat may occur in hypertrophy, dilatation or displacement of the heart.

The size of the heart should be determined by percussion. The left heart border in infants is usually ½ to ⅔ centimeter outside the nipple line; the right border is at the right sternal margin, or even slightly to the right of it; the upper border is at the upper border of the second rib, and the lower

limit is at the 4th or 5th interspace. The apex beat is best seen or palpated at the nipple line or slightly to the right of it. In older children the left heart border is in the left nipple line or slightly outside of it and the right heart border at the mid-sternum. When the child is in the sitting position, the heart falls forward and may show a wider area of dullness. The heart tones in infants and children are louder than in adults and may at times give the impression of a murmur. When a murmur is present, it should be noted whether it is systolic or diastolic in time. No murmur should be considered merely functional unless it is proved to be so by long observation. Absence of heart tones, weakening of heart tones and friction rubs, all of which occur in various forms of pericarditis, should be carefully noted.

Lungs.—The number of respirations per minute, the ease or difficulty of breathing, the depth or shallowness of the respiration, and the comparison of the expansion of both sides of the chest may, at times, tell at a glance whether or not there is any disease of the respiratory system in general, and of the lungs in particular. Further means of diagnosis are percussion and auscultation.

In normal infants the percussion note over the lungs is higher pitched than in adults. Decreased resonance or dullness is present in consolidation of the lungs, as in pneumonia, or in effusion of the pleura, as in empyema and tuberculous pleurisy. It may also be present in compression of the lungs, as in pericarditis with effusion. In order to recognize decreased resonance, it is important to compare the dull area of the lungs with the corresponding region on the other side.

The breath sounds in infants and children are also higher pitched than in adults. The type of breathing found in infants is spoken of as "puerile" and resembles bronchial breathing. The skilled physician, however, can differentiate between puerile, or normal breathing, and between bronchial breathing, present in pneumonia and compression of the lung due to pericarditis. Large râles, present in acute bronchitis, and small, moist râles, present in bronchopneumonia, should be carefully noted.

The D'Espine sign should be elicited in children suspected to be suffering from mediastinal obstruction, such as enlarged tracheobronchial glands. The sign consists of determining the lowest area to which the whispered voice is transmitted by auscultation. The method of eliciting the sign is as follows: The child is seated in a chair, or held in the nurse's lap, with its head bent forward. The stethoscope is placed over the various dorsal vertebra, and the child is asked to count 1, 2, 3. The vertebra at which the whispered voice is no more transmitted is noted.

Normally, the whispered voice is transmitted down to the second dorsal vertebra. In the presence of enlarged bronchial glands, or other mediastinal obstructions, the whispered voice is transmitted as low down as the 5th or 6th dorsal vertebra.

Abdomen.—The shape of the abdomen should be observed for enlargement such as occurs in rickets, in congenital syphilis, in inflammations, new growths of the liver and kidneys and in generalized peritonitis. The abdo-

men should also be examined for fluid which is present in decompensation of the heart and in new growths of the viscera. Notice should be taken of the presence of tympanites found in many infectious diseases, and of retraction of the abdomen which often accompanies wasting diseases, especially tuberculosis.

The abdomen should be palpated for areas of tenderness and of rigidity. In infants with severe vomiting, reversed peristalsis, present in pyloric stenosis, should be looked for. Umbilical hernia, frequent in rickets and mongolian idiocy, should also be noticed.

An attempt should be made to outline the stomach and to palpate the liver and spleen. The stomach can be outlined either by percussion alone,

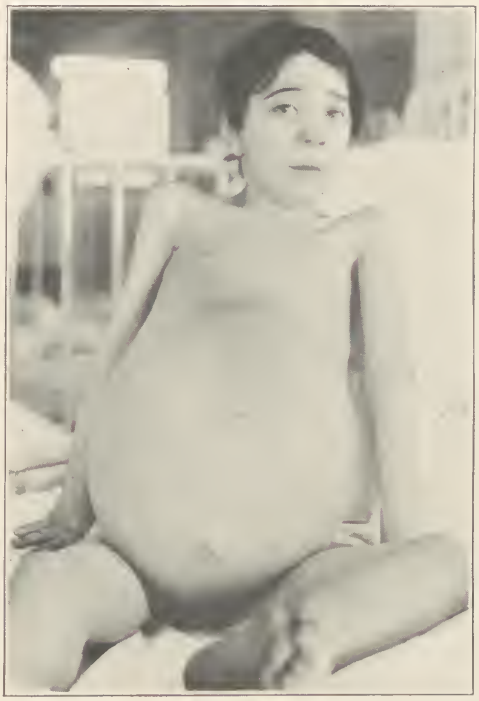

Fig. 17.—Abdomen in case of decompensated heart.

by eliciting a tympanitic note over the stomach area or by combined percussion and auscultation. In using the latter method the stethoscope is firmly held over the stomach region, and the area surrounding the stethoscope is scratched lightly with the nail of the index finger of the free hand. A high-pitched or amphoric sound, due probably to the air in the stomach, is elicited by the scratching over the stomach area. The tone becomes dull as soon as the lower border of the stomach is reached. A little experience will prove this method to be very practicable, especially when dilatation of the stomach is looked for.

Appendicitis in infants and children does not produce the marked rigidity observed in adults. Absence of rigidity, therefore, does not exclude ap-

pendicitis. On the other hand pneumonia is frequently accompanied by marked rigidity. Not every rigid abdomen therefore is an operative case.

The liver and spleen should be palpated for enlargement and tenderness. This is best done by an up and down stroke of the examiner's hand, with the patient in the recumbent posture, and with his knees drawn up (Fig. 18). Enlargement of the liver and spleen may also be detected by percussing the abdomen.

Normally, the liver cannot be palpated, or may be felt at the costal margin, the latter frequently being the case in infants. The liver is enlarged in some cases of icterus, in congenital syphilis, heart disease, in malignant diphtheria, Banti's disease, and various tumors.

The spleen cannot be felt in normal infants and children. It is enlarged in a multitude of diseases, notably syphilis, rickets, malaria, typhoid, leukemia, Banti's disease, and various forms of sepsis, hemolytic anemia, and splenic anemia.

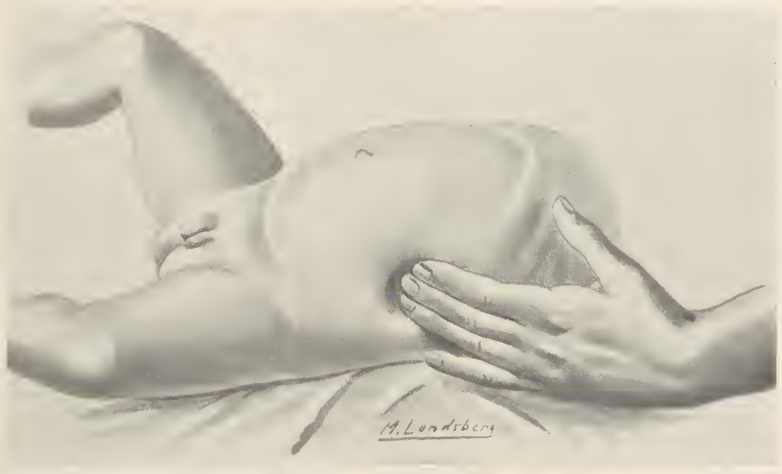

Fig. 18.—Method of palpating the spleen.

The anus and rectum should be examined both by inspection and digital palpation. The latter may reveal the presence of a polyp of the rectum or of a mass in the pelvic cavity.

Genito-Urinary Organs.—Phimosis and undescended testicles in the male, and vaginitis in the female should be looked for. Inguinal hernia should be looked for by introducing the index finger into the external inguinal ring, and telling the child to cough or making him cry.

Spine.—Tender spots and deformities, such as kyphosis, lordosis, scoliosis and abscesses should be looked for.

Extremities.—Notice should be taken of the position of the extremities and the ease with which the child moves them. Any change from the normal position or normal motion should be further investigated. A child suffering from scurvy, epiphyseal separation due to lues, inflammation of the bones or joints holds the affected extremity in a resting position. In spastic paralysis,

the extremities are rigid, in flaccid paralysis they are flaccid. In spasmophilia, the extremities show a carpopedal spasm. Notice should also be taken of the ratio of the extremities in relation to the rest of the body as an altered ratio may signify endocrine disturbance. Observation should also be made as to inequality of the extremities, such as is present in tuberculosis of the hip and knee, and anterior poliomyelitis; of the presence of epiphyseal

Fig. 19.—Spina ventosa.

Fig. 20.—Clubbed fingers in child with a congenital heart lesion.

enlargement, such as is present in rickets; of tenderness, such as is the case in the early stages of acute poliomyelitis, grippe, scurvy and periostitis; of edema and desquamation; of spina ventosa or tuberculous osteomyelitis of the metacarpals (Fig. 19) and of clubbed fingers, present in endocarditis or bronchiectasis (Fig. 20). The nails should also be examined for brittleness and onychia.

Nervous System.—The general attitude of the patient, the exaggeration or absence of the patellar, achilles, biceps and triceps reflexes and of the cremasteric and abdominal reflexes should be noted. Observation should also be made as to the presence of facial, radial and ulnar reflexes, the presence of Babinski's, Brudzinski's and Kernig's signs and the presence of paralysis, ataxia, or choreiform movements.

The importance of the attitude of the patient has been discussed above. The patellar reflex which is elicited by tapping immediately below the patella is exaggerated in many normal infants and children and should therefore not be considered pathologic unless the exaggeration is unilateral. The absence of the patellar reflex, however, should make one suspect acute anterior poliomyelitis, postdiphtheritic paralysis or juvenile tabes.

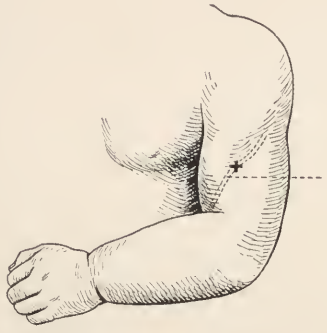

Fig. 21.—Elicitation of the radial nerve reflex.

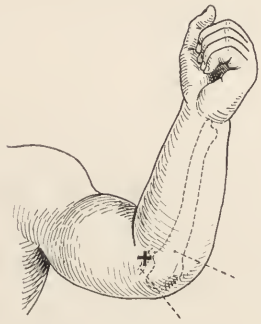

Fig. 22.—Elicitation of the ulnar nerve reflex.

The achilles reflex which consists of contraction of the foot by percussing over the tendo achillis is exaggerated in tetany and is absent in poliomyelitis and postdiphtheritic paralysis. The same is true with regard to the triceps reflex, elicited by tapping over the tendon of the triceps above the olecranon process of the ulna, and the biceps reflex elicited by tapping the tendon of the biceps over the head of the radius. Ankle clonus is present in some neurotic infants and children. The cremasteric reflex is often absent in normal infants and is therefore of no pathologic significance. The abdominal reflex is present and often even exaggerated in infants. Its absence therefore signifies pathology. The pupillary light and accommodation reflex is very important in that its absence always denotes pathology.

In tetany, when the face is tapped at the angle of the inferior maxilla, there is a twitching of the eyelid and the adjacent facial muscles. This is known as the Chvostek sign.

The radial reflex (Fig. 21) which consists of a twitching of the fingers produced by tapping the arm ½ to ¾ of an inch above the olecranon process is positive in tetany. The same is true of the ulnar reflex (Fig. 22).

The Babinski sign is elicited by stroking the sole of the foot and observing the action of the big toe. Normally, there is a complete plantar flexion of all the toes. In meningeal or encephalitic irritation, there is an extension of the big toe with flexion of the other toes. It should be remembered, however, that the Babinski sign is normally present during the first six months of life.

The Brudzinski sign consists of flexing the patient's head on the chest while the patient's legs are extended. In meningitis or meningism the patient's thighs flex on the trunk.

Kernig's sign consists of bending the thigh on the trunk and extending the leg. If the leg cannot be extended beyond a right angle, or when the extension causes severe pain, it is a sign of meningeal irritation.

If paralysis is present, notice should be taken as to the extent of the paralysis, whether or not it is limited to any part of the body, or if it is spastic or flaccid in type.

Temperature, Pulse, and Respiration.—No examination of a child is complete without determining the temperature, pulse, and respiration. The temperature in normal infants and children varies between 98° and 99° F., with an average of 98.6° when taken by mouth, and 99° when taken by rectum. Elevation of temperature is noticed in all infections, also in thirst, such as in the newborn. Reduction of temperature is present in premature infants, state of shock, and other conditions producing emaciation. Before a reduction of temperature is pronounced, it should be made certain that the thermometer has been in the body cavity for a sufficient length of time to register.

In order to obtain still more information from the temperature, it should be taken three times, or at least twice a day. It is then possible to differentiate between the continuous fever, such as is the case in infections due to pneumococcus, and the remittent fever, such as is the case in infections due to streptococcus, staphylococcus or tubercle bacillus.

The pulse in infants varies between 90 to 120 per minute. In older children it varies between 80 to 100 per minute. Sleep lowers the pulse rate; exercise or excitement increases the pulse rate. As a rule, the increase in pulse rate runs parallel to the height of temperature. Typhoid and paratyphoid constitute the exception to this rule. In all brain affections the pulse is usually slow. In pancarditis, the pulse is irregular. In myocardial affections the pulse often skips, and is soft in quality.

The rate of respiration in children is best counted when the patient is asleep, as excitement increases the respiratory rate. In infants, the respira-

tion varies between 24 to 30 per minute, and in older children between 20 to 26 per minute. Fever, due to any cause, increases the respiratory rate. Children with diabetic coma or severe infections of the respiratory tract have shallow respirations.

Other Examinations.—To complete the examination, the urine and blood should be examined, and a tuberculin test should be made. In some cases, a nose and throat culture should be taken. All of these examinations will be discussed under their respective headings.

CHAPTER III

PEDIATRIC INSTRUMENTS AND LABORATORY SUPPLIES

The following constitute the most important pediatric instruments in private practice.

1. Thermometer.
2. Stethoscope.
3. Tongue Depressors.
4. Culture Media.
5. Slides.
6. Test Tubes.
7. Blood Cell Counter.
8. Head Mirror.
9. Ear Specula or Auroscope.
10. Paracentesis Knife.
11. Catheters to be used for:
    (a) Lavage and Gavage.
    (b) Enemata.
    (c) Urethral Catheterization.
12. Spinal Puncture Needle.
13. Thoracocentesis Needle.
14. Intravenous Needles.
15. Small Intracutaneous Needles.
16. Syringes:
    (a) Tuberculin.
    (b) Large.
17. Pirquet Scarifier.
18. Intubation Outfit.
19. Tracheotomy Tube.
20. Small Percussion Hammer.
21. Scales.
22. Blood Pressure Apparatus.
23. Tissue Finger Cots.
24. Proctoscope.
25. Ophthalmoscope.

I shall discuss each one of these instruments:

Thermometer.—A physician who practices among children should carry a mouth and a rectal thermometer. It is best to use rectal thermometry on all children under ten years of age as the rectal temperature is always more accurate than the mouth temperature. The axillary temperature is unreliable. A rectal thermometer should be introduced gradually following the outline of the rectum and avoiding striking the folds in the mucous membrane.

There are special rectal thermometers on the market, most of them with a protruding bulb at the lower end. The bulb serves to make the thermometer more easily distinguishable from the oral thermometer and the blunt end makes piercing of the rectal tissue less probable.

Many physicians use vaseline as a lubricant for the introduction of the thermometer into the rectum. Plain cold water, however, will answer the purpose. What is more important than the lubricant is to use an antiseptic solution for the thermometer, so as not to transmit infection from one patient to another. It has been pointed out that the thermometer may be one of the means of transmitting infection. The conscientious physician should therefore keep this point in mind. Dipping the thermometer in lysol, bichloride of mercury, or alcohol and washing it in cold water before using will answer the purpose.

Stethoscope.—The stethoscope used for the examination of children is the same as that for adults except for slight improvements which should be made in order to avoid discomfort. The mouthpiece should either be of rubber or of aluminum or steel covered with rubber in order not to shock the baby by the cold end of the stethoscope. The broad end of a nursing

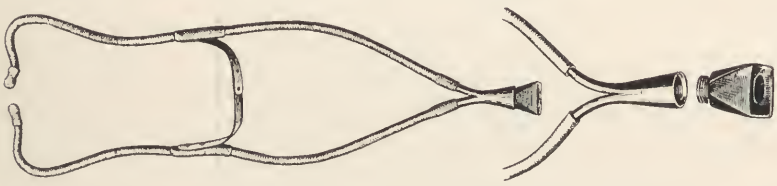

Fig. 23.—Special stethoscope for laryngeal auscultation.

rubber nipple may be used to cover the mouthpiece. The rubber tubing should be long enough to prevent the physician from coming too close to the patient, especially if the patient is suffering from a contagious disease.

A special bell has been described to be used in laryngeal auscultation for the purpose of differentiating laryngeal diphtheria from laryngitis (Fig. 23). This, however, is not absolutely necessary.

Tongue Depressor.—Of the many tongue depressors in use, the most common and most popular is the flat wooden stick. This tongue depressor has the advantage of being cheap, and therefore makes possible the use of a separate tongue depressor for each child. It has, however, several disadvantages. It becomes soiled when carried in the pocket. The shape of the wooden stick also interferes somewhat with its usefulness, for, being flat, it does not depress the tongue of the infant very well and, causing the weight to fall on the tip of the tongue, it makes it possible for the child to contract the tongue and obliterate the view of the pharynx. Several years ago, I devised a tongue depressor which is so constructed that, when it is inserted into the mouth of the child, the child cannot pull the tongue away. The tongue depressor is made of nickel wire with two bars in the center and is curved at the end in order to depress the base of the tongue (Fig. 24). When placed into the child's mouth it gives a clear view of the tongue, the tonsils,

the pharynx, and the upper part of the larynx. It also makes examination for Koplik's spots a simple procedure.

When no tongue depressor is at hand, the handle of a teaspoon will answer the purpose.

Culture Media.—No physician who works with children should be without a supply of culture media of either Loeffler's blood serum or glucose agar, for they form a simple and a most essential diagnostic means whenever the question of diphtheria has to be decided upon. Of the many ways in which throat cultures are put up, the most convenient is in a tin box as is supplied by the Chicago Health Department, together with sterile swabs, and a card of information for the laboratory. The tin box is superior to the test tube as a container of Loeffler's serum for throat culture, for a test tube is apt to break or the cotton plug may easily fall out. Besides, cultures dry up much sooner in a tube than in a box and the box is less bulky. Other

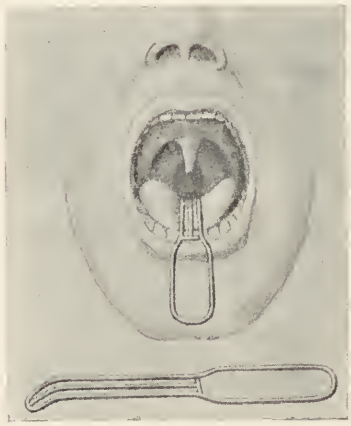

Fig. 24.—Tongue depressor for infants.

media are supplied by commercial houses in sealed tubes which keep sterile and are effective for a long period.

Slides.—Slides offer a valuable means of diagnosis. They are not so valuable for the diagnosis of diphtheria as a throat culture, but they are extremely important in the diagnosis of Vincent's angina and of conjunctivitis and vaginitis. Slides are also used for differential white counts. When a specimen is put on a slide, it is advisable to flame the slide in order to fix it. It can then be stained later.

Test Tubes.—Test tubes of different sizes should be carried by the physician for the collection of cerebrospinal fluid, pus and urine. As test tubes break easily, it is best to carry them in wooden or tin containers.

Blood Counter.—The fact that leucocytosis serves as a means of differential diagnosis of diseases, as between measles and scarlet fever, for example, makes a white blood count a necessity in pediatric practice. Whenever a regular blood counting outfit is not obtainable, a leucocyte pipette should at least be carried, so that the blood can be drawn, mixed with the diluting

fluid and brought to a laboratory for examination. The examination should be made within two or three hours after collection of the specimen.

Head Mirror or Otoscope.—Although a head mirror seems to belong in the realm of the ear specialist, no pediatrician can afford to get along without one. The ear is so often the source of obscure fevers and it is so often involved in the course of other diseases, that it behooves every pediatrician to carry a head mirror or otoscope with him. The head mirror need not be very large, nor must it necessarily have a band.

Ear Specula.—Examination of the ears in infants and children also requires the use of small specula. The ear specula on the market are usually too large for a child's ear. In fact, the difficulty of procuring small-sized specula seems to discourage many physicians from making routine ear examinations in children. Some pediatricians have trained their eyes to such a degree that they can focus the light on the drum by simply pulling the pinna of the ear upward without the aid of an ear speculum. However, this is not within the power of every physician, and wherever possible the physician should therefore make use of ear specula. Steel specula are preferable to rubber ones as they are more durable.

Nasal specula may be used in examination of children. Care must, however, be taken not to injure the mucous membrane of the nose by the speculum. A regular ear speculum, especially when attached to the handle of an electric otoscope, makes an ideal nasal speculum. A bent hairpin may also be used for nasal examination. The examination of the larynx or postnasal spaces with a head mirror is so difficult in children that it should be attempted only in rare instances. Laryngeal mirrors are seldom necessary in pediatric practice. Digital examination answers the purpose of postnasal examination and laryngeal examination should, whenever possible, be referred to the laryngologist.

Paracentesis Knife.—To complete the necessary outfit for ear work in children, a paracentesis knife is desirable. A two-piece paracentesis knife is preferable to a long one-piece instrument, as the former is carried about more easily.

Catheters.—Two or three catheters of different sizes should be carried by every pediatrician, to be used for lavage and gavage; 12, 14 and 18 French usually answer the purpose.

Rectal Tube.—A long, rectal tube is often of great value both in diagnosis and treatment. It may serve as a means of diagnosing intestinal obstruction, and it is frequently the means of relieving a convulsion by permitting thorough evacuation of the bowel. A physician should carry one of these tubes in his grip.

Duodenal Catheter.—This instrument, which was described for the diagnosis of pyloric stenosis. consists of a long, thin catheter (Nélaton No. 15 French) with a glass bulb at one end. The tube is first introduced into the stomach and then pushed ahead to the duodenum and the bulb is drawn upon. If the tube is in the duodenum, the examiner should be able to draw

up bile into the glass bulb. If no bile can be drawn up, pyloric stenosis is probable. Although it requires skill to be able to insert the duodenal catheter into the duodenum, it is an art that can be mastered in a short time, and it is one that well repays learning, for it serves as a valuable aid in diagnosis.

Urethral Catheter.—Children do not require urethral catheterization as frequently as adults, yet there are occasions when they do need it, and it would be well for the physician to possess one for such emergencies. The catheter for male infants should be of soft rubber. For females, a modified steel eustachian catheter may be used.

Spinal Puncture Needle.—Spinal puncture is so useful a procedure in the diagnosis and treatment of various conditions that every physician should be prepared to do this operation, if we may call it so, on the spur of the moment. Although each package of antimeningitis serum usually contains a spinal puncture needle, a physician should carry one or more spinal puncture needles in his grip all the time. The needle for children should be of a slightly larger diameter than the needle used for adults, as the child may have a purulent meningitis and the spinal fluid may be so thick that it cannot get through a small opening.

Thoracocentesis Needle.—The surest diagnosis of empyema is made by means of thoracocentesis. A wide needle with a large lumen should therefore be carried by the physician. It is best to use a syringe with the needle, so as to be able to aspirate the pus. A needle alone, however, may suffice, the pus oozing through the lumen.

Small Needles.—Nowadays so many tests are performed by the aid of the small needle that it is necessary to be supplied with a number of them for pediatric work. The intracutaneous tuberculin, the Schick, and the luetin tests necessitate the use of small needles. It should be remembered, however, that the point of the needle used should be short, otherwise the fluid to be injected is apt to run out. The diameter of the needle should also be very small (26-27 gauge).

Syringes.—If one can afford to have several syringes of different sizes, it is well to do so. However, if one finds it impracticable to have more than one he should choose the tuberculin syringe. This syringe, graduated to one one-hundredth of a cubic centimeter is practically indispensable for quantitative tuberculin tests, the Schick, the luetin tests, and for the administration of vaccine. This syringe can also be used for thoracocentesis.

Pirquet Scarifier.—In the majority of cases there is no need of doing an intracutaneous test for the purpose of determining whether a child has a tuberculous infection. A cutaneous test will usually do. For this test the Pirquet scarifier is of great assistance. This instrument consists of a platinum stylet and a rather heavy handle. The longer the handle the easier to scarify and the better. Of course, when no Pirquet scarifier is to be had, an ordinary needle will do, although the reaction is not so defined as when done by the scarifier.

The Pirquet scarifier is used by some physicians for smallpox vaccination. The result is much neater than when the operation is done with a needle.

Intubation Outfit.—Antitoxin excepted, intubation has saved more babies' lives from the scourge of diphtheria than any other means of treatment. Even to this day when antitoxin is so commonly used, intubation steps in every once in a while as a life-saving measure. A physician who expects to practice pediatrics should have an intubation set with him for emergency work. There are two popular outfits on the market: The O'Dwyer and the Ferroud. The O'Dwyer consists of hard rubber tubes lined with metal sheeting, an obturator for each tube, and a separate introducer and extractor. The Ferroud instrument consists of metal tubes with one instrument to be used both for intubation and extubation. Both sets have a mouth gag that is used for keeping the child's mouth open during the operation. Either type of instrument can be used to good advantage. The hard rubber tubes, it is true, are less liable to produce ulceration of the larynx than the metal ones. However, used repeatedly, they are apt to break off. I witnessed such an occurrence at one time. Generally speaking, however, either rubber or metal tubes may be used with equal success provided proper care is taken to see that the tube is not used too many times and that it is not permitted to stay in the larynx too long.

Tracheotomy Tube.—When intubation fails, tracheotomy can still be resorted to as a life-saving measure. In some respects, tracheotomy is simpler than intubation and it may be done by any physician. The mortality, however, is much higher in tracheotomy than in intubation, principally because the child is forced to breathe in cold air, which makes him more susceptible to pneumonia. Another factor responsible for the higher mortality of tracheotomy is the fact that it is usually the last resort, after all other measures have failed, the child being thoroughly exhausted by that time. The best tracheotomy tube is one made of silver or aluminum, not of lead.

Scales.—For the physician a scale is often as important an article as it is for the grocer. This is particularly true in connection with infant feeding, where a scale tells instantly how much food the infant gets from the breast, what the food is doing for him, and whether it is necessary to increase or decrease the amount. A scale registering in grams is best, but rather expensive. For a few dollars, however, one may obtain a nursery scale that answers the purpose very well.

A few years ago, Pirquet devised a "Measuring Band" to be attached to the wall. It contains figures giving the weight of boys and girls according to their ages, and according to their corresponding height. Unfortunately it is very hard to procure this measure in this country.

Small Percussion Hammer.—Although it is quite possible to get along without a percussion hammer, this instrument is very useful for eliciting reflexes in infants. A number of small flexible hammers have been put on the market. A simple percussion hammer can be made of thick glass rod bent at a sharp angle and padded with a piece of rubber at the shorter end.

Blood Pressure Apparatus.—The ordinary blood pressure apparatus on the market, with a small cuff to fit the child's arm, can be used to advantage for measuring the blood pressure. It must be kept in mind, however, that blood pressure determination in children is not very accurate.

Proctoscope.—The proctoscope used for children should have a narrow lumen. An electrically lighted urethroscope makes a good proctoscope for children.

Ophthalmoscope.—An electrically lighted ophthalmoscope is preferable to an ordinary ophthalmoscope as the movements of the child's eye can be followed more easily.

Obsolete Instruments.—There are a number of instruments which at one time or another had been very popular, both with the laity and the profession, and which added experience showed to be unnecessary and at times even harmful. Most important of these instruments are the lactometer and the tongue-tie cutter.

Years ago nobody dared to practice pediatrics without an instrument for the determination of fat in milk, especially mother's milk. We have learned since that the value of the chemical constituents changes in different portions of the milk and that a complete chemical analysis and not a hurried clinical examination will determine the various amounts in the milk. The lactometer, therefore, is a useless instrument.

Years ago many children's tongues were cut as a remedy for many evils. As a matter of fact, very few children are tongue-tied, and the instrument that was at one time used for cutting the tongue may easily be left out of the physician's armamentarium.

Laboratory Supplies

The following supplies are necessary for routine clinical laboratory examinations in pediatric practice.

utensils

Microscope—including coarse and fine adjustments, low and high power and oil immersion lens. Cedar oil and xylol are necessary for the proper use of the oil immersion lens.

Centrifuge—electric or handrun for urine and cerebrospinal fluid examinations.

Test tubes—large—for urinalysis and pus collection; small—for cerebrospinal fluid. Test tube holders and test tube rack are serviceable.

Slides and *cover slips* for blood, urine, and exudates.

Esbach tube for quantitative determination of albumin in urine.

Litmus paper—pink and blue, for determination of reaction of urine.

Urinometer—for determination of specific gravity of urine.

Fermentation tube—for confirmation of sugar in urine.

Funnels and *filter paper* for filtration of urine.

Blotting paper for blotting stained slides.

Pipettes—1 and 10 c.c. capacity for cerebrospinal fluid and urine.

Burette—25 and 50 c.c. capacity for quantitative determination of sugar in urine. Also stand and clamp for burette.

Bunsen burner or alcohol lamp for boiling urine and heating slides.

Tripod—wire mat or gauze and stirring rods—for quantitative sugar.

Evaporating dishes—for determination of chlorides and sugar in urine.

Incubator—for bacteriologic work. Vest pocket may, however, serve as incubator in case of emergency.

STAINS

Methylene blue—good for staining nearly all organisms.

Loeffler's alkaline methylene blue, best for diphtheria.

Gentian-violet, Gram's iodine, 95 per cent alcohol, saffranin—for Gram's stain.

Carbol fuchsin, Acid alcohol—for tubercle bacilli.

Wright's stain—for blood cells.

Hayem's solution—for red cell count.

Toison's solution—for leneeeyte count.

CHEMICALS

Acetic acid—glacial, 3 per cent, 0.3 per cent—for determination of albumin in urine, for counting leucocytes and for bringing out diphtheria granules in smears.

Concentrated nitric acid—for albumin in urine.

Benedict's qualitative solution, Haines' solution, or *Fehling solution*—for testing the presence of sugar in urine.

Benedict's quantitative sugar solution—for quantitative sugar determination in urine.

Anhydrous sodium carbonate—for Benedict's sugar test.

Esbach's reagent—for quantitative albumin in urine.

Sodium nitroprusside crystals
Concentrated ammonium hydroxide } for acetone in urine.

Guaiac powder
Benzidine
Hydrogen peroxide } for detection of blood in urine and stool.
(in dark bottles).

Alcohol, 95 per cent. *Ether. Chloroform.*

Ferric Chloride, 10 per cent, for testing diacetic acid in urine.

Diazo reagents 1 and 2 for the Diazo test.

Formaldehyde for quantitative determination of ammonia, also a preservative.

Saturated ammonium sulphate (neutral)
Butyric acid 10 per cent
Carbolic acid solution, 1-16 } for determination of increase of globulin in cerebrospinal fluid.

CHAPTER IV

EXAMINATION OF BLOOD

INDICATIONS FOR EXAMINATION OF BLOOD

In every disease of infancy and childhood no matter what condition is suspected, the patient's blood should be examined. In many cases, the examination may be limited to the cell elements and hemoglobin for which only a few drops of blood are required.

If congenital or acquired syphilis is suspected, a Wassermann test should be done on the blood. For this purpose, 3 to 5 c.c. of blood should be removed from the patient.

If diabetes is suspected, the blood sugar should be determined. The amount of blood required for this examination depends on the chemical method employed. For the Lewis-Benedict or the Folin-Wu method, 2 c.c. is required; for the Kowarsky method, 0.5 c.c. and for the Epstein method 0.2 c.c. suffice.

If nitrogen retention is suspected, the blood should be examined for the amount of nonprotein nitrogen for which 2 c.c. of blood is required. Some consider the uric acid determination as even more important than the nonprotein nitrogen. The amount of blood required varies between 2 to 4 c.c. depending on the method used. Urea nitrogen also requires 2 c.c. of blood. To throw light on the prognosis of nephritis creatinine should be determined. This examination requires 3 c.c. of blood. All constituents of nonprotein nitrogen of clinical importance may, however, be examined by taking only 5 c.c. of blood.

When acidosis is suspected, as in severe cases of diabetes, diarrhea or infections, the blood should be examined for the alkali reserve or its CO_2 combining power, for which 0.5 to 5 c.c. of blood is required, depending on the method.

In rickets and tetany the calcium content of the blood may be examined; 3 to 5 c.c. being required for the examination.

Of some clinical importance is also the determination of cholesterol in diabetes for which examination 3 c.c. of blood is required, and the determination of chlorides in nephritis with threatening edema for which examination 0.1 to 0.2 c.c. of blood is required.

METHODS OF OBTAINING BLOOD

When only a few drops of blood are required, as for the determination of the cell elements, hemoglobin and coagulation-time, the blood can be obtained by piercing the lobe of the ear or the finger with a sharp scalpel or needle. When larger quantities of blood are required such as for the Wassermann test and blood chemistry, the blood may be obtained by making a large incision with a scalpel in the patient's heel or intrascapular region and applying an old-fashioned dry cup for withdrawing the blood. Both of these

methods, although practiced by some physicians are, however, time-consuming and are unsatisfactory, especially for blood chemistry. In such cases, it is best to withdraw blood from some vein in the body.

In older children it may be possible to remove blood for examination from a vein on the arm or at the ankle. The technic is the same as that in adults which is as follows: The bend of the elbow or the internal surface of the ankle is selected as the site of puncture. A tourniquet (a soft rubber tube, a wide strip of gauze or even a handkerchief), is applied around the limb, 1 to 1½ inches above the point of puncture. The tourniquet should be tight enough to obstruct the venous, but not the arterial circulation. The limb is held by an assistant or is rested on the edge of a table and the area of operation is washed with alcohol and iodine. A 16- to 18-gauge needle,

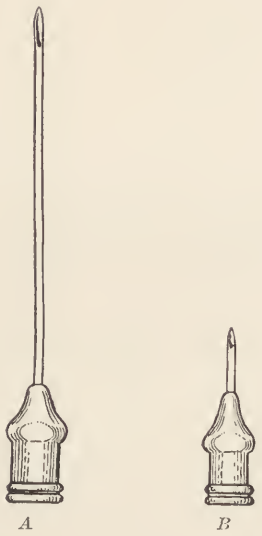

Fig. 25.—Needles employed for removal of blood from the median basilic or external jugular veins *(A)* and from the longitudinal sinus *(B)*. Needles are shown in their actual size.

1 to 1½ inches in length (Fig. 25*A*), fastened to a dry syringe is now introduced under the skin overlying the vein and is pushed forward into the vein. The skin over the vein is preferably rolled between the thumb and index finger of the operator's left hand to facilitate the introduction of the needle into the vein. As soon as blood appears in the syringe, the plunger of the syringe is withdrawn carefully until the desired amount of blood is obtained (Fig. 26). The tourniquet is now removed and a gauze bandage is applied around the limb over the area of puncture. No collodion is necessary.

In infants and young children in whom the veins are too small or cannot be distinguished on the skin, blood may be withdrawn from the jugular vein or from the longitudinal sinus. It should be remembered that the longitudinal sinus may form a thrombus so that whenever possible other avenues should be used for obtaining blood.

Jugular Vein Puncture.—The child's arms are held closely to the trunk by a tightly wrapped sheet or blanket, the upper edge of which reaches only to the shoulders. The child is placed in the recumbent posture on a table

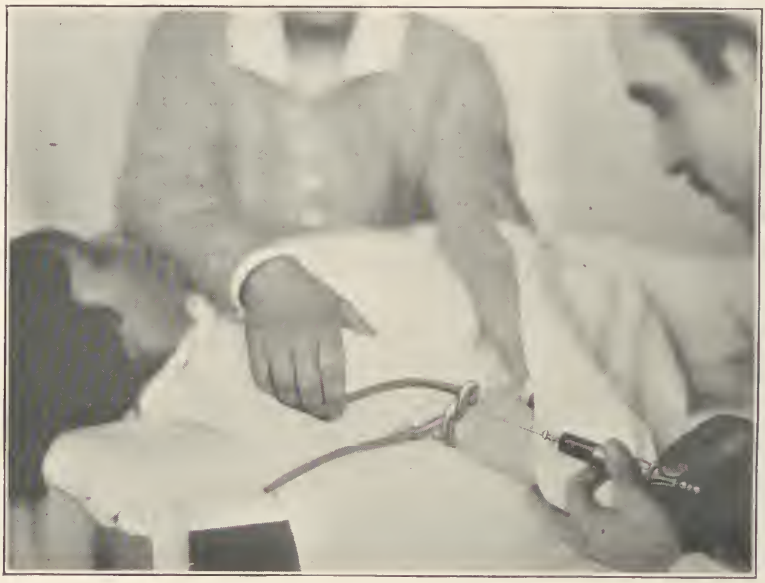

Fig. 26.—Removal of blood from median basilic vein.

Fig. 27.—Removal of blood from the external jugular vein.

with a small pillow or pad under the shoulders, allowing the head to fall slightly backwards. The chin is turned to the shoulder, thus bringing the jugular vein into prominence and into the most accessible position. It may be made to stand out more prominently by the application of pressure just

above the clavicle. The skin is cleaned with iodine and alcohol. A 16- to 18-gauge needle, 1 to 1½ inches in length, attached to a 10 c.c. syringe is introduced into the outstanding vein. The needle is introduced from above downward in a line with the vein (Fig. 27). It is best to pierce the needle by the first thrust through the skin only and then slowly introduce the needle into the vein and withdraw the plunger of the syringe.

Longitudinal Sinus Puncture.—The child is placed in the recumbent posture with the head at the edge of table. A sheet is enveloped around the child to prevent struggling. The hair over the anterior fontanelle is shaven and the scalp over this area is washed with alcohol and ether. A 16- to 18-gauge needle, ¼ to ½ inch in length (Fig. 25*B*), attached to a syringe is now introduced at the lowermost portion of the posterior angle of the

Fig. 28.—Removal of blood from longitudinal sinus.

fontanelle, the needle pointing slightly backwards for a distance of ¼ to ⅜ of a cm. When the longitudinal sinus is reached, dark red blood appears in the syringe (Fig. 28). The desired amount of blood is now slowly withdrawn, the needle removed and collodion applied to the puncture. If blood continues to ooze from the opening, the patient's head should be raised on a higher level than the rest of the body. If even this does not stop the bleeding, a tight bandage should be applied around the head.

Prevention of Clotting.—For the determination of the cell elements, hemoglobin and Wassermann test, no precaution has to be taken to prevent the blood from clotting. For the chemical analysis of the blood it is important that the blood remain unclotted. For this purpose sodium citrate, potassium oxalate or lithium oxalate should be used, the two latter being preferable. In using potassium oxalate, 0.4 c.c. of a 2 per cent solution is employed for 5 c.c. of blood and 0.8 c.c. of a 2 per cent solution for 10 c.c. of blood.

The oxalate solution is allowed to dry in the oven at the bottom of the bottle in which the blood is to be collected. A very simple although less accurate way of preventing clotting of the blood is to put 2 to 3 crystals of potassium oxalate in the test tube in which the blood is to be collected. Lithium oxalate, which is considered the best anticoagulant, can be prepared only where good laboratory facilities are available.

Containers.—The blood should be collected directly from the needle in the vein or from the syringe into a wide-mouthed specimen bottle, of about 20 c.c. capacity. The receptacle should contain no water, for water tends to change the volume. Constant shaking of the bottle is necessary while the blood is being collected so that the blood may be thoroughly mixed with the anticoagulant.

Time Element.—For chemical examination blood should be withdrawn from the patient before breakfast, as food has a tendency to increase the concentration in the blood of the chemical substance to be examined. It has been found, for instance, that blood sugar increases in amount right after the ingestion of food and that the increase continues from one to two hours. The same is true to a lesser degree of urea. The blood should be examined as soon as possible after it has been removed from the body, at least within three hours.

Table I

Removal of Blood for Diagnostic Purposes

Determination	Amount necessary	Method of removal
Cell count Differential count	Few drops	Ear or toe by sharp scalpel or needle
Coagulation	1 to 2 drops	" "
Wassermann test	3 to 5 c.c.	Cut in heel Needle in median vein (older children) Needle in jugular vein or longitudinal sinus (in infants)
Blood chemistry		
Nonprotein nitrogen 2 c.c. Urea nitrogen 2 c.c. Creatinine 3 c.c. Uric acid 2 c.c.	5 c.c. for determination of nonprotein nitrogen and its constituents	Same as for Wassermann except that an anticoagulant must be added
Sugar 1 c.c.		
Cholesterol 3 c.c.		
Chlorides 0.1 to 0.2 c.c.		
Alkali reserve 0.5 to 5 c.c.		Cut in heel or needle in vein
Blood culture 5 c.c.		Needle in vein
Blood matching 2 drops to 1 c.c.		Ear, toe, heel or vein
Fragility few drops to 2 c.c.		" "

Technic of Cell Counting.—

1. *Red Cell Count.*—After piercing the ear or finger with a sterilized needle or scalpel, blood is drawn up in the red blood cell pipette (1-101) to mark 0.5 and Hayem's solution (Mercuric Chloride 0.5 gm.; sodium sulphate 5.0 gm.; sodium chloride 2.0 gm.; distilled water 200 c.c.) to mark 101. The pipette is shaken and a drop is placed in the counting chamber.

The cells contained in 100 small squares are counted and the number obtained is multiplied by 8000, or the cells in 80 squares are counted and the result multiplied by 10,000 by adding four zeros to the number obtained. This gives the red cell content per cm.

2. *White Cell Count.*—Blood is drawn up in the white cell counting chamber (1-11) to mark 0.5 and acetic acid (1.5 per cent) to mark 11. The cells in several squares are counted, the average for one square obtained and this number is multiplied by 200, to get the content of white cells per cm.

3. *Differential Cell Count.*—A drop of blood is spread on a slide with the edge of a cover-glass or of another slide or with cigarette paper. After the blood has dried in the air, the smear is covered with Wright stain for one minute followed by the addition of distilled water, drop by drop, for 4 or 5 minutes, depending on the strength of the Wright stain. The slide is then washed off with plain water, blotted and examined. At least 100 white cells should be counted and recorded. The red cells should be noted for their shape, presence or absence of nuclei and for abnormal cells. The white cells should be counted according to their types (small and large lymphocytes, transitional, neutrophiles, eosinophiles and basophiles). Bacteria and parasites should also be noted.

Interpretation of Cell Elements in Blood.—There are several important points to be kept in mind in connection with the determination of the cell elements in the blood of children.

Table II

Example of the Distribution of the Cell Elements in the Blood of Infants and Children

AGE	HB.	RED	WHITE	N	SM.	LM.	T	E
3 days	95	7,500,000	17,200	49	34	15	12	
7 weeks	90	3,980,000	8,200	14	77	5	3	1
next day	90	4,100,000	9,800	21	70	4	5	
next day	80	4,000,000	9,860	11	81	3	3	2
3 months	85	4,300,000	10,000	12	67	12	5	1
6 months	80	4,400,000	12,200	22	63	13	2	0
8 months	75	4,200,000	11,500	37	41	18	3	1
3 years	90	4,600,000	13,200	46	38	4	6	6

The number of red blood cells is high in the newborn, usually reaching over 6,000,000 per cm. and is low during infancy and childhood, averaging 4,000,000 per cm. No diagnosis of anemia should therefore be made in infants and children unless the red cells are markedly below 4,000,000 per cm. In newly born babies, especially those born prematurely, or those showing marked jaundice, nucleated red blood cells are commonly found. Later in infancy and childhood, however, nucleated red cells indicate a pathologic condition.

The leucocytes in the newborn vary between 15,000 to 20,000 per cm., 60 to 70 per cent of the number being polymorphonuclear in type. From the second week of life, extending all through infancy and childhood, the number of leucocytes varies between 10,000 and 15,000, with a preponderance of

lymphocytes, the number of lymphocytes varying between 40 to 60 per cent. The eosinophiles vary between 1 and 3 per cent. Transitional cells range between 2 and 6 per cent except in the newborn when their number may be still higher (Table II). The blood platelets vary between 250,000 to 300,000 per cm. all through infancy and childhood.

Leucocytosis by itself means very little if anything, unless it is very high, such as 20,000 to 25,000. Leucocytosis with a relative neutrophilia indicates infection. Leucopenia is important because of its presence in measles, german measles, chicken pox, influenza and typhoid (Table III). It must be understood, however, that the leucopenia is present only in certain stages of these diseases, usually in the early stages, the blood changing to a leucocytosis toward the end of the disease or when complications take place.

TABLE III

LEUCOCYTIC CHANGES IN ACUTE INFECTIOUS DISEASES IN CHILDREN

Scarlet	Marked leucocytosis and neutrophilia, beginning with the prodromal symptoms, rising still higher on appearance of rash and gradually declining with improvement of the patient. Lymphocytes are diminished, increasing gradually with improvement. Eosinophiles are increased during eruptive stage, at times reaching 25 per cent.
Measles	Leucopenia and neutrophilia returning to normal when rash is fully developed.
German Measles	Leucopenia and relative lymphocytosis.
Chicken Pox	Leucopenia and neutrophilia.
Diphtheria	Leucocytosis and neutrophilia. Eosinophiles diminished or absent.
Erysipelas	Leucocytosis and neutrophilia in proportion to severity of disease. Eosinophiles diminished or absent.
Mumps	Moderate leucocytosis and lymphocytosis.
Grippe	Leucocytosis and neutrophilia.
Epidemic Influenza	Leucopenia and lymphocytosis early. Neutrophilic leucocytosis lasting several days on recovery or on onset of complication.
Pertussis	Leucocytosis and lymphocytosis.
Pneumonia	Marked leucocytosis and neutrophilia. Leucocytes ranging between 20,000 to 80,000; neutrophiles ranging between 70 to 98 per cent. Eosinophiles absent throughout disease but reappear on day of crisis.
Meningococcus Meningitis	Leucocytosis and neutrophilia.
Typhoid	Leucopenia and lymphocytosis. Eosinophiles diminished or absent. There is often a leucocytosis on the first day of the disease.
Malaria	Leucopenia and relative lymphocytosis.

An eosinophilia over 4 per cent is present in eczema, asthma or intestinal parasites, reaching in some cases as high as 20 to 30 per cent. On the other hand, eosinophiles are absent in certain infectious diseases (Table III).

Arnett index and Opsonic index, at one time quite popular, are not commonly employed now as a clinical aid. The same is true with inclusion bodies at one time considered specific for scarlet fever.

Hemoglobin.—Hemoglobin is most easily determined by the Talquist hemoglobinometer, an instrument sufficiently accurate for clinical purposes.

At birth and the first few days of life the hemoglobin is usually over 100 per cent compared to the adult standard. It may reach as high as 135 per cent. During infancy, however, the hemoglobin is usually below that of the normal adult. During the school age the hemoglobin varies between 70 and 80 per cent. This anemia is spoken of in the literature as "school anemia." This possibly results from the overexertion and fatigue to which many modern school children are subjected. No diagnosis of organic anemia or disease of the blood should be made on the mere lowering of hemoglobin. One must take into consideration the number and type of cells, the hemoglobin and the color index (Table IV).

Table IV

Blood Findings in Anemias of Infants and Children

TYPE	RED CELLS	HB.	COLOR INDEX	WHITE CELLS	TYPE OF WHITE BLOOD CELLS	ABNORMAL CELLS
Secondary anemia	Diminished according to degree of anemia	Diminished	1 or below	Slightly increased	Lymphocytes relatively increased	Poikilocytosis
Von Jaksch anemia	Diminished; 2,000,000 or less	Diminished to 20-25%	Normal or below	Increased; 25,000 to 60,000	Mono- or polymorphonuclear Eosinophiles increased	Nucleated red; mainly normoblasts; in severe cases megaloblasts
Acute lymphatic leukemia	Diminished; 2,000,000 to 1,000,000	20 to 30%	1 or below	Greatly increased; 50,000-100,000	Lymphocytosis 90-98%; chiefly large lymphocytes	
Chronic lymphatic leukemia	Diminished; 2,000,000 to 1,000,000	Diminished	1 or below		Lymphocytosis; chiefly small lymphocytes	
Splenomyelogenous leukemia	Diminished; 2,000,000 to 1,000,000	Diminished; 20 to 30%	1 or below	50,000 to 200,000	Neutrophiles relatively increased Eosinophiles increased	Myelocytes and mast cells in large numbers
Chlorosis	Diminished; 3,500,000 to 2,500,000	35 to 40%	1 or below	Normal	Lymphocytes relatively increased	Poikilocytosis
Pernicious anemia	Greatly diminished. May fall to less than 1,000,000	Diminished as low as 20%	Above 1	Markedly diminished	Lymphocytes relatively increased	Nucleated red; more megaloblasts than normoblasts; Poikilocytosis

Coagulation.—Coagulation of blood is both an interesting and an important phenomenon. It is interesting to see a body tissue which is in a liquid state while in the body coagulate as soon as it leaves the body. Normally blood coagulates in 5 to 10 minutes after it leaves the body. Jaundice, sepsis, syphilis and hemophilia retard the coagulation of blood. In the first three diseases, the delay of coagulation is due to the hemolytic processes going on in the blood.

Technic.—The simplest method is to put a drop of blood on a watch crystal and determine the coagulation time by running a horsehair or pin through it.

The following table from Ottenberg shows the importance of coagulation in differential diagnosis (Table V). Of utmost importance is the determination of coagulation time in surgery. No operation should be performed on a child without previous determination of the coagulation time of the blood.

TABLE V

COAGULATION AS AN AID IN DIFFERENTIAL DIAGNOSIS OF HEMORRHAGIC DISEASES IN CHILDREN

	COAGULATION	BLEEDING TIME	PLATELETS
Hemophilia	Greatly prolonged	Normal or plus	Normal
Hemorrhage of newborn	Greatly prolonged	Prolonged	
Purpura hemorrhagica	Normal	Greatly prolonged	Greatly decreased
Purpura, secondary to			
1. Jaundice	Prolonged		
2. Chloroform	Prolonged		
3. Scurvy	Normal	Normal	Normal
Purpura simplex, Arthritic purpura, Visceral purpura	Normal	Normal	Normal

The mechanism of hemophilia is still unknown. It has been found, however, that there are two types of hemophilia; one due to calcipriva, and another due to thrombopriva. In the first type of cases, the calcium in the blood is diminished, and in the other type, the calcium in the blood is normal, but the amount of thrombin is lessened.

Therapeutically, it is often desirable to prevent coagulation of the blood. This is most important in cases where large quantities of blood have to be transfused into a child. Two-tenths per cent sodium citrate has been found useful in preventing coagulation.

BLOOD CULTURE.—A positive blood culture is of great assistance in diagnosis as it ascertains the causative organism, providing it is known that the culture medium was not contaminated. A negative blood culture does not exclude the presence of bacterial organisms in the blood. Blood culture is usually most positive early in the disease. This is especially true in typhoid and pneumonia. It is found to be most positive when the patient has a high temperature.

Technic.—Five to ten c.c. of blood is withdrawn from the median or jugular vein or from the longitudinal sinus, by means of a syringe (method described above). The blood is introduced into a flask containing 100 or 200 c.c. of sterile glucose broth warmed to body temperature. This is incubated for 24 hours and examined for bacteria. The culture should be returned to the incubator and examined at intervals of 24 hours for a period of one week. This should be done in order to detect the more slowly growing organisms occasionally encountered, such as a poorly growing Streptococcus viridans.

Agglutination.—When blood serum agglutinates a certain bacterial organism, it may be taken as evidence that the body is invaded by that particular organism.

Agglutination is mainly used in the diagnosis of typhoid, paratyphoid and dysentery. The agglutination test for typhoid is known as the Widal test. The technic is as follows:

A drop of blood serum or dried blood is diluted with 24 drops of normal salt solution. A drop of suspension of typhoid bacilli, which may be obtained from commercial laboratories, is now added to the diluted blood and examined on a hang-drop slide or on a flat slide. If the patient suffers from typhoid fever, the typhoid bacilli clump and if living bacilli are used, they become motionless in a few minutes.

The reaction may be obtained macroscopically by adding typhoid organisms to diluted blood serum and allowing to incubate overnight.

The Widal test is usually negative during the first week of the disease but becomes positive at the beginning of the second week and remains positive for months and years. A positive Widal, therefore, means that the patient either has or has had typhoid. It is advisable to repeat a positive Widal test one week later. If found more strongly positive (with greater dilution) it speaks for an active typhoid.

Pneumococcus agglutination is used to determine the type of pneumococcus invading the body after the organism has been isolated from the blood. If Type I is found, serum may be given to the patient. Type III is considered fatal.

Blood Matching.—Blood transfusion is used very frequently in pediatric practice in cases of sudden or gradual loss of blood. It has been found that the serum of a small percentage of individuals will clump the red blood cells of certain other individuals. In order to avoid any accidents, it is necessary to group or match the blood of the donor and of the recipient to ascertain that the serum of the patient would not agglutinate the corpuscles of the donor and *vice versa*. A number of methods have been described for blood grouping and blood matching. For practical purposes, the method of Lee or that of Kimpton will suffice.

Method of Lee.—A small amount of blood is collected from the patient (1 c.c. from the ear or finger is sufficient) and allowed to clot. The serum is then obtained. One drop of this serum is placed on a slide and mixed with a drop of a suspension of blood of the donor taken into 1.5 per cent citrate solution. (A few drops of blood are taken into approximately ten times the amount of 1.5 citrate solution and shaken. It is very important that the blood be dropped directly into the citrate, and should not be coagulated partially.) The result will appear in a few moments and is best examined under the microscope, where in the event of a positive test, marked agglutination will be evident. The reaction will also be evident macroscopically. In the event of a negative result it is a wise precaution to raise the cover-glass, and after making sure that the serum and cells are well mixed, to examine the preparation again. The only possible source of confusion is the appearance of rouleaux of the red

corpuscles, indicating too thick an emulsion. If the test is negative, transfusion may be regarded as entirely safe.

Method of Kimpton.—Two to three drops of the donor's blood is collected into a small tube containing 0.5 per cent oxalate or salt solution (Solution 1). The oxalate prevents coagulation, thus keeping the corpuscles free.

Two to three drops of the donor's blood is collected into 0.5 c.c. of distilled water (Solution 2). This destroys the red blood cells and preserves the serum.

The above procedures are repeated with the recipient's blood. (Solution 3 = corpuscles and Solution 4 = serum.)

A drop of the donor's corpuscles (Solution 1) is now placed on a hang drop slide with a drop of the recipient's serum (Solution 4). The procedure is repeated with the donor's serum (Solution 2) and the recipient's corpuscles (Solution 3). The slide is observed under the microscope for clumping. Often clumping may be observed even with the naked eye. If clumping is present, the donor's blood cannot be used for transfusion.

Harp found that isoagglutination is rarely present at birth and during the first month of life. According to his findings, no test would have to be made on blood to be transfused to an infant during the first month of life. Harp's findings are disputed by other investigators.

Fragility of Blood Corpuscles.—Normally red blood cells do not hemolyze in salt solution above a dilution of 0.44 per cent. In hemolytic condition of the blood, the cells hemolyze with a higher salt solution even as high as 0.6 to 0.8 per cent,—in other words the cells are fragile. It is claimed that the type of jaundice can be differentiated by the fragility of the blood cells; hemolytic jaundice making the blood more fragile, obstructive jaundice producing no change in their resistance. The test cannot be considered specific, although it serves as corroborative evidence.

Wassermann Test.—Although a positive Wassermann test may be obtained occasionally in diseases other than syphilis such as in leprosy, jaundice or even in the early stages of scarlet fever, a 4-plus positive Wassermann test should be taken as an indication of an existing luetic infection, providing the test has been done with more than one antigen. A doubtful positive test should always be repeated. A negative Wassermann test does not exclude syphilis as the infection may be too recent in origin, may have subsided under treatment or may be localized in the central nervous system. In the latter case the cerebrospinal fluid Wassermann may be positive in spite of the negative reaction in the blood.

Occasionally the Wassermann test is negative in cases where clinical symptoms point to congenital or acquired syphilis. In such cases the test may be made more effective by giving the child a dose of neosalvarsan or several mercuric rubs, and the Wassermann repeated. Such a test is called provocative Wassermann.

Blood Chemistry

The chemical substances in blood of known clinical value are: sugar, nonprotein nitrogen, urea nitrogen, uric acid, creatinine, cholesterol, chlo-

rides, calcium and phosphorus. Of these, the first five mentioned are most commonly determined.

The most commonly employed system of blood analysis is that of Folin and Wu. Because of the rapidity of the methods and the small amount of blood needed in this system of analysis, it seems preferable to other methods. I shall therefore describe it here as used with slight modification at the Michael Reese Hospital chemical laboratories. For detailed accounts one should refer to the original work of Folin and Wu. It should be remembered, however, that because of the small amount of material needed and because of the personal factor entering into the reading of colorimeters, a slight inaccuracy in the method may mean a large percentage of error in the final results.

Removal of Proteins.—In determining sugar, nonprotein nitrogen, urea, uric acid and creatinine in the blood, the protein must first be coagulated. The following method is used: To a measured quantity of oxalated blood, (2 to 8 c.c. depending on the determinations desired) are added seven volumes of water, one volume of 10 per cent sodium tungstate, and one volume of 2/3 normal sulphuric acid, the latter to be added slowly from a burette while shaking the flask. The mixture is allowed to stand for at least five minutes, to coagulate the proteins. The color of the precipitate should now change from red to dark brown or chocolate. If the change in color does not occur, the blood has not been coagulated completely, most likely because too much oxalate has been used in obtaining the specimen. In such cases, 2 per cent normal sulphuric acid should be added drop by drop and the coagulum shaken after each drop until the color changes to chocolate. The mixture is now filtered through a large, dry filter. The clear, colorless filtrate is used for the various examinations. If the filtrate is to stand 24 hours or longer before examination, a drop or two of toluol should be added.

Determination of Blood Sugar.—Into a Folin sugar tube (pyrex), graduated at 25 c.c. (Fig. 29) should be introduced 2 c.c. of blood filtrate and 2 c.c. of alkaline copper tartrate solution.[1] Into another tube should be introduced 2 c.c. of a standard sugar solution[2] containing 0.1 mg. of glucose per c.c., and 2 c.c. of alkaline copper tartrate. The standard and unknown are heated together in boiling water for six minutes, after which they are placed in cold water for two minutes. To each tube is then added 2 c.c. of molybdate phosphate solution[3] and water is added after two minutes to the 25 c.c. mark.

[1] *Alkaline Copper Tartrate Solution.* Forty grams of anhydrous sodium carbonate is dissolved in about 400 c.c. of water. This is transferred to a one liter volumetric flask. Now 7.5 grams of tartaric acid are added. When dissolved, 4.5 grams of crystallized copper sulphate are added, mixed and made up to the mark.

[2] *Standard Sugar Solution.* A stock solution is made by dissolving 1 gm. of pure glucose in 100 c.c. of benzoic acid solution (2.5 gm. benzoic acid in 1 liter of boiling water, allowed to cool). Before using, it is diluted with 0.3 per cent benzoic acid one to one hundred. For each blood determination 1 c.c. of the stock solution is introduced into a 100 c.c. volumetric flask, and benzoic acid is added to the mark. Two c.c. of this standard, containing 0.1 mg. of glucose per cubic centimeter, is used.

[3] *Phosphomolybdic Acid Solution.* Thirty-five grams of molybdic acid and 5 grams of sodium tungstate are placed in a liter beaker, 200 c.c. of 10 per cent sodium hydroxide and 200 c.c. of water are added. This is boiled vigorously for twenty to forty minutes to remove nearly all of the ammonia present in the molybdic acid, cooled, diluted to about 350 c.c., and 125 of 85 per cent phosphoric acid added and diluted to 500 c.c.

The solutions are mixed well and after standing for at least five minutes the unknown is read against the standard in the colorimeter, setting the standard at 20.

The sugar is calculated from the formula:

$$\frac{20 \times 100}{\text{Reading}} = \text{mgs. of sugar per 100 c.c. of blood.}$$

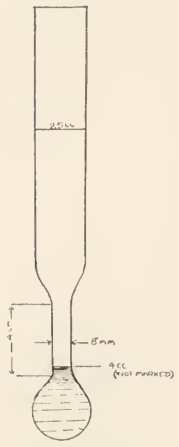

Fig. 29.
Folin sugar tube.

Sugar Tolerance.—In addition to the determination of sugar on one specimen of blood, the sugar tolerance test may be employed for the detection of diabetes and of endocrine disturbances. The sugar tolerance test consists of the determination of the blood sugar at repeated intervals, namely, before the ingestion of sugar, and ½ hour, 1 hour, 2 hours, 3 hours and 4 hours after the ingestion of sugar.

One and one-half gm. of glucose is given to each kilogram of body weight. The sugar is given in water or in lemon juice on an empty stomach. In normal individuals, the blood sugar rises from normal, (80 to 120 mg. per 100 c.c.) to 130-180 mg. one hour after the ingestion of the sugar, and returns to normal within 2 or 2½ hours. No sugar appears in the urine.

In diabetes the blood sugar rises to 300 mg. or even higher in ½ to 2 hours and it takes several hours before it returns to normal.

In endocrine disturbances, the rise in the sugar curve is even slower than normal, the patient having an increased tolerance for sugar.

Determination of Nonprotein Nitrogen.—Five c.c. of blood filtrate is introduced into a pyrex digestion tube, which is calibrated at 25 c.c. and 50 c.c., and 1 c.c. of acid digestion mixture[4] is added. A glass bead is put in to prevent bumping. The mixture is now heated rapidly over a microburner until the water is boiled off. When white fumes appear the tube is covered with a small watch crystal and heated slowly at the boiling point until the solution assumes a pale green color, or at least until it fumes two minutes. The contents are allowed to cool for 60 to 90 seconds and water is then added, drop by drop at first and then to about 30 c.c. While cooling, the standard should be prepared as follows:

Into a 100 c.c. volumetric flask is introduced 3 c.c. of an ammonium sulphate solution containing 0.3 mg. of nitrogen[5], 2 c.c. of the acid digestion mixture, and water to about 50 c.c.

Fifteen c.c. of Nessler's solution[6] are now added slowly, with constant

[4] *Acid Digestion Mixture.* Three hundred c.c. of 85 per cent phosphoric acid is mixed with 100 c.c. of concentrated sulphuric acid (free from ammonia). This is transferred to a tall cylinder, covered well to prevent absorption ammonia, and set aside for at least a week to permit sedimentation of calcium sulphate. To 100 c.c. of the clear acid mixture 100 c.c. of water and 10 c.c. of 6 per cent copper sulphate solution is added.

[5] *Standard Solution* of ammonium sulphate. Specially purified ammonium sulphate, 0.4716 g., is dissolved in 1000 c.c. of distilled water. Ten c.c. of this solution contains 1 mg. of nitrogen. For blood standard 3 c.c. is used. Toluol is added as a preservative.

[6] *Nessler's Solution.* One hundred gm. of mercuric iodide and 70 gm. of potassium iodide are introduced into a liter volumetric flask and 400 c.c. of water added. One hundred gm. of sodium hydroxide dissolved in 500 c.c. of water and cooled thoroughly is now added to the mixture in the flask, and water is added to make up a liter. The small amount of red precipitate should be allowed to settle at the bottom and the supernatant fluid should be used.

shaking, to the unknown and 30 c.c. to the standard. The blood filtrate and standard should be nesslerized about the same time. Distilled water is added to the mark and the contents of the flasks mixed thoroughly.

If the blood filtrate solution is cloudy, due to the suspensions of particles of silica from the glass, it should be centrifuged. The solution is now read in the colorimeter against the standard solution of ammonium sulphate, setting the standard at 20.

The nitrogen content is calculated from the formula:

$$\frac{20 \times 30}{\text{Reading}} = \text{mg. of nitrogen in 100 c.c. of blood.}$$

Determination Urea Nitrogen.—Into a pyrex nitrogen tube are introduced 5 c.c. of the blood filtrate, two drops of pyrophosphate buffer mixture[7] and 1 c.c. of urease solution.[8] The tube is placed in water at 40° to 55° C. and allowed to stand for 5 minutes or left at room temperature for 15 minutes. Two c.c. of saturated borax solution are then added to render the solution alkaline. Five drops of paraffin oil and a glass bead are also added to prevent foaming. The mixture is distilled into a pyrex test tube graduated at 25 c.c. containing 2 c.c. of twentieth normal hydrochloric acid, the distillation consuming 5 minutes. The distillate is cooled under the tap. A standard solution is made up by placing in a 100 c.c. volumetric flask, 3 c.c. of the standard ammonium sulphate solution and about 60 c.c. of water. Standard and unknown are then nesslerized, the standard receiving 10 c.c. and the unknown 2.5 c.c. The standard is then made up to the 100 c.c. mark and the unknown to the 25 c.c. mark.

Urea nitrogen is calculated from the formula:

$$\frac{\text{St} \times 15}{\text{R}} = \text{mg. per 100 c.c. blood.}$$

Determination Creatinine.—Ten c.c. of the protein-free blood filtrate are measured into a large test tube. Into another tube are introduced 5 c.c. of a standard creatinine solution[9] (containing 0.03 mg. of creatinine), and 15 c.c. of water. A fresh alkaline picrate solution is prepared by mixing 15 c.c. of saturated freshly recrystallized picric acid and 3 c.c. of 10 per cent sodium hydroxide purified by alcohol. This solution is then added to standard and unknown, 10 c.c. to the former and 5 c.c. to the latter. Both are allowed to stand for 10 minutes before reading in the colorimeter, the standard being set at 20.

Calculate from the formula:

$$\frac{20 \times 1.5}{\text{Reading}} = \text{mg. per 100 c.c. blood.}$$

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[7]*Buffer mixture.* Seventeen and two-tenths gm. of monosodium phosphate and 44.8 gm. of crystallized disodium phosphate are dissolved in 200 c.c. of warm distilled water. The solution is cooled and diluted to 250 c.c. One or two drops of Toluol is added as a preservative.

[8]*Urease Solution.* About 3 gm. of permutit powder are washed with 2 per cent acetic acid, then twice with water. Five grams of Jack bean meal and 100 c.c. of 15 per cent alcohol (16 c.c. of ordinary alcohol and 84 c.c. H_2O) are added. The flask is stoppered and shaken gently but continuously for 15 minutes after which it is filtered through a large dry filter. It should be kept in a cold place. The solution then keeps about a week at room temperature and four to six weeks in an ice box.

[9]*Creatinine Standard Solution.* A stock solution containing 1 mg. of creatinine per c.c. (used also for determination of creatinine in urine) is made up by dissolving 1.61 gm. of creatinine zinc chloride in 1 liter of N/10 HCl acid. Six c.c. of this solution are measured into a liter volumetric flask, 10 c.c. of normal HCl added and water to the mark. Toluene is used as a preservative.

Determination of Uric Acid.—Into a test tube graduated at 25 c.c. is measured 5 c.c. of blood filtrate. Into another such tube is measured 5 c.c. of standard uric acid solution containing 0.02 mg. of uric acid.[10] To each is added 2 c.c. of water, 2 to 3 drops of 20 per cent lithium sulphate solution[11] and 2 c.c. of sodium cyanide solution.[12] One c.c. of uric acid reagent[13] is added to each, the solutions are mixed and allowed to stand for two minutes. They are then placed in boiling water for 80 seconds, cooled in running water and made up to the mark with water, mixed and read against the standard which is set at 20.

$$\frac{20 \times 4}{\text{Reading}} = \text{mg. of uric acid per 100 c.c. of blood.}$$

Determination of Chlorides.—Into a small Erlenmeyer flask is measured 0.115 c.c. of blood plasma and 1.6 c.c. of N/100 silver nitrate solution.[14] To this is added 10 drops of chloride-free concentrated nitric acid. The mixture is then warmed carefully and saturated potassium permanganate solution is added drop by drop until the color it produces remains. The solution is boiled carefully for five minutes and then dextrose is added drop by drop until the color disappears. When cool, the silver chloride should settle at the bottom in little lumps and the supernatant liquid should be colorless. The excess silver nitrate is then titrated with N/100 ammonium thiocyanate solution,[15] four to five drops of saturated ferric ammonium sulphate solution being used as indicator.

Chlorides are calculated from the formula:

$$\frac{\text{c.c. of silver nitrate} - \text{c.c. of thiocyanate used}}{\text{volume of blood used (0.115 c.c.)}} \times 0.0585 =$$

gm. of NaCl per 100 c.c. of blood.

Determination of Cholesterol.—With constant shaking 3 c.c. of blood are run slowly into a 100 c.c. volumetric flask containing about 80 c.c. of redistilled alcohol and ether (3:1). The mixture is heated to boiling on a

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[10] *Standard Uric Acid Solution.* A stock solution is made up as follows: Exactly one gram of uric acid is transferred to a funnel on a 300 c.c. flask. From 0.45 to 0.5 gm. of lithium carbonate is placed in a 300 c.c. beaker, 150 c.c. of water is added, and the mixture heated to 60° C. with constant stirring to dissolve the salt. The uric acid is then rinsed into the flask and with shaking dissolves practically at once. As soon as a clear solution is obtained, it is cooled under running water with shaking, and transferred to a liter volumetric flask, rinsed and diluted to 400 to 500 c.c. Twenty-five c.c. of 40 per cent formaldehyde are added and after shaking, 3 c.c. of glacial acetic acid. The solution is shaken to remove most of the carbonic acid, diluted to volume and mixed. It should be tightly stoppered and kept in the dark.

For use it is diluted 1:250 as follows: 1 c.c. is transferred to a 250 c.c. volumetric flask half full with water. Ten c.c. of 2/3 NH_2 SO_4 and 1 c.c. of 40 per cent formaldehyde are added, diluted to the mark and mixed.

[11] *Lithium sulphate solution.* Twenty gm. of powdered lithium sulphate are dissolved in about 80 c.c. of cold water. It is diluted to 100 c.c. and filtered.

[12] *Sodium cyanide solution* (approximately 15 per cent in N/10 NaOH). One hundred to 150 gm. of cyanide are transferred to a large beaker and 6.7 c.c. of N/10 NaOH is added for each gram taken, stirring occasionally until dissolved.

[13] *Uric acid reagent.* (a) Fifty c.c. of 85 per cent phosphoric acid and 160 c.c. of water are transferred to a 500 c.c. Florence flask. This is heated nearly to boiling and then 100 gm. of sodium tungstate is added. This is boiled gently but continuously for one hour over a microburner using a 200 c.c. flask filled with cold water on a funnel as a condenser.

(b) In a liter beaker is placed 25 gm. of lithium carbonate. Fifty c.c. of phosphoric acid and 200 c.c. of water are added carefully. The carbon dioxide gas is boiled off and the mixture is cooled. Solutions (a) and (b) are mixed and diluted to 1 liter.

[14] *N/100 silver nitrate solution.* 1.699 gm. per liter.

water-bath, with occasional shaking. It is then cooled under the tap, made up to 100 c.c. with the alcohol-ether mixture, and filtered through a dry filter.

Ten c.c. of this extract are measured into a small beaker and evaporated just to dryness on a water-bath. The cholesterol is extracted from the dry residue by boiling out three or four times with 2 to 3 c.c. of chloroform and decanting into a beaker. The combined extracts are evaporated to less than 5 c.c. and transferred to a glass stoppered 10 c.c. graduated cylinder. The volume is made up to 5 c.c. with chloroform.

TABLE VI

CHEMICAL CONSTITUENTS OF BLOOD IN MG. PER 100 C.C.

Nonprotein Nitrogen	25.00– 40.00
Urea Nitrogen	12.00– 20.00
Uric Acid	1.00– 4.00
Creatinine	0.9 – 2.0
Amino Acids	4.8 – 7.8
Sugar	80.00–120.00
Chlorides	500.00–600.00
Cholesterol	150.00–175.00
Calcium	10.0 – 11.5
Phosphorus (Inorganic)	4.8 – 6.8

Into another graduated cylinder are introduced 5 c.c. of a standard cholesterol solution,[16] containing 0.5 mg. of cholesterol. To both standard and unknown are added 2 c.c. of acetic anhydride and, drop by drop, 0.1 c.c. of concentrated sulphuric acid. The solutions are carefully mixed and set in the dark for 15 minutes after which they are read in the colorimeter. The standard is placed at 15.

Cholesterol is calculated from the formula:

$$\frac{25 \times 100}{\text{Reading}} = \text{mg. per 100 c.c. blood.}$$

INTERPRETATION OF BLOOD CHEMISTRY.—Blood sugar in children is approximately the same as that of adults, namely, 0.08 per cent to 0.12 per cent. These figures vary with the intake of food, being higher after a meal. A marked increase in blood sugar without previous ingestion of food indicates diabetes. This is of greater significance than the reduction test in urine, as the latter might not always indicate the presence of a sugar, for as is well known, salicylates and other drugs might cause a reduction of the urine by copper sulphate. There is also the condition known as renal diabetes occurring in nondiabetic individuals. In this condition there is a glycosuria without any increase of blood sugar.

Nonprotein nitrogen of blood in children usually runs between 25 to 40 mg. per 100 c.c. of blood. This is increased in uremia and in acute and chronic nephritis with nitrogen retention. Schloss found a marked increase in nonprotein nitrogen in cases of intestinal intoxication.

[15] *N/100 ammonium thiocyanate solution.* 0.761 gm. per liter.

[16] *Cholesterol Standard.* A stock solution of 0.2 gm. of cholesterol in 200 c.c. chloroform is diluted 1:10 with chloroform giving the standard solution for use.

TABLE VII

CHEMICAL BLOOD CHANGES IN VARIOUS DISEASES OF CHILDHOOD

	NEPHRITIS			UREMIA	DIABETES	ALIMENTARY INTOXICATION	RICKETS	TETANY
	WITH NO NITROGEN RETENTION	WITH NITROGEN RETENTION	WITH EDEMA					
Nonprotein nitrogen	Normal	Increased	May or may not be normal depending on whether or not there is nitrogen retention	Greatly increased	Normal	May be increased	Normal	Normal
Urea	"	"	"	"	"	"	"	"
Uric acid	"	"	"	"	"	"	"	"
Creatinine	"	Increased if prognosis is grave	"	Increased if prognosis is grave	"	"	"	"
Sugar	"	Normal	Normal	Normal	Increased	"	"	"
Chlorides	"	"	May be increased	"	Normal	Normal	"	"
Cholesterol	"	May or may not be normal	May or may not be normal	May be slightly increased	May be increased	"	"	"
Acetone	"	"		May be increased	"	"	"	"
Calcium	"	Normal	Normal	Normal	Normal	"	"	lowered
Phosphorus	"	"	"	"	"	"	lowered	Normal

Urea nitrogen varies in normal infants and children between 12 to 20 mg. per 100 c.c. of blood. In other words, it constitutes about 50 per cent of the nonprotein nitrogen.

Uric acid varies between 1-4 mg. per 100 c.c. of blood. Uric acid often is the first nonprotein nitrogenous product to be retained in the blood. Creatinine has a very important prognostic significance. An increase of creatinine to 5 mg. usually means a bad prognosis. An increase in other nonprotein nitrogen constituents may not necessarily mean a bad prognosis.

Cholesterol varies between 150 to 175 mg. per 100 c.c. of blood. It is increased in diabetes and occasionally also in nephritis.

Blood chlorides vary between 500 to 600 mg. per 100 c.c. of blood, figured as sodium chloride. They are often increased in nephritis with edema and may be decreased proportionally in the urine.

Acetone and diacetic acid are normally present only in small traces, while in uremia and diabetes they may be present in large quantities.

CHAPTER V

DETERMINATION OF ACIDOSIS

Normally, the blood is slightly alkaline. The reaction is usually expressed in terms of pH, blood having a pH of 7.4 to 7.6 compared to distilled water which is neutral or of pH 7.0. Although the blood is only slightly alkaline so far as its reaction is concerned, it has the power of neutralizing quite a large amount of strong acid before its reaction is changed. This power of the blood is due to the presence in the blood of sodium bicarbonate, disodium hydrogen phosphate and alkaline salts of proteins, which are known as "buffer substances." They constitute the so-called alkaline reserve of the blood.

In diabetes, some forms of alimentary disturbances, and in some febrile conditions large amounts of acids are formed in the body. The body at-

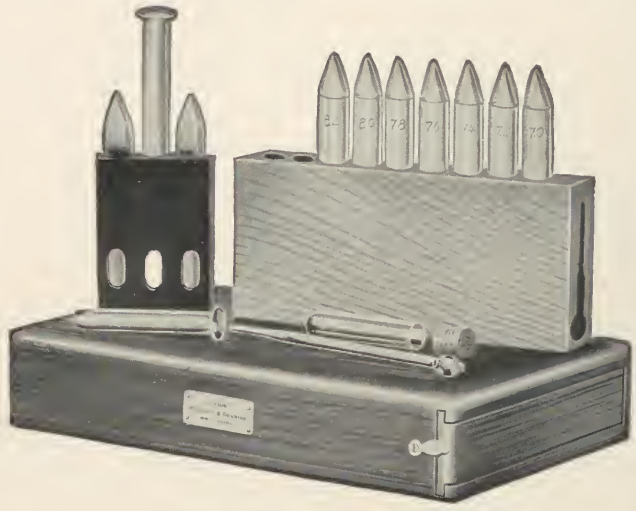

Fig. 30.—Alkali reserve tubes.

tempts to remove these acids by an increased respiratory ratio, removing CO_2 by way of the lungs. It also attempts to remove the acids by way of the kidneys in the form of acid phosphates and also in the form of ammonium salts of acids. An increased acidity of the urine, an increased ammonia content of the urine, the presence of certain abnormal acids and a decreased tension of alveolar air, all may indicate the presence of acidosis. Some do, however, reserve the term acidosis to a lowered alkaline reserve in the blood. As pointed out elsewhere, the presence of acetone and diacetic acid merely indicates the presence of a ketosis, still in the presence of clinical signs, these acids point to the presence of an acidosis. The urinary tests for acidosis are described in the chapter on urine; here I shall describe the methods for and interpretation of alveolar air tension and alkaline reserve content of the blood.

Alkali Reserve.—Normally the alkali reserve varies between 40 to 63 per cent of CO_2 at "O" temperature and 750 barometric pressure. The alkali reserve is expressed in terms of RpH.

Method.—Either the Van Slyke and Cullen apparatus or the Marriott colorimetric method may be used. The microapparatus of Van Slyke is more applicable to children's work than the macroapparatus, as only 0.2 c.c. is required in the former apparatus. The Marriott method is more frequently used in clinical work, because the colorimeter is portable and readily obtainable.

The Marriott method consists of dialyzing whole blood, or blood serum, against a salt-indicator solution having a pH of 7.0, and comparing the resulting color change with standard indicator tubes. A set of these standard tubes may be obtained from physicians' supply houses.

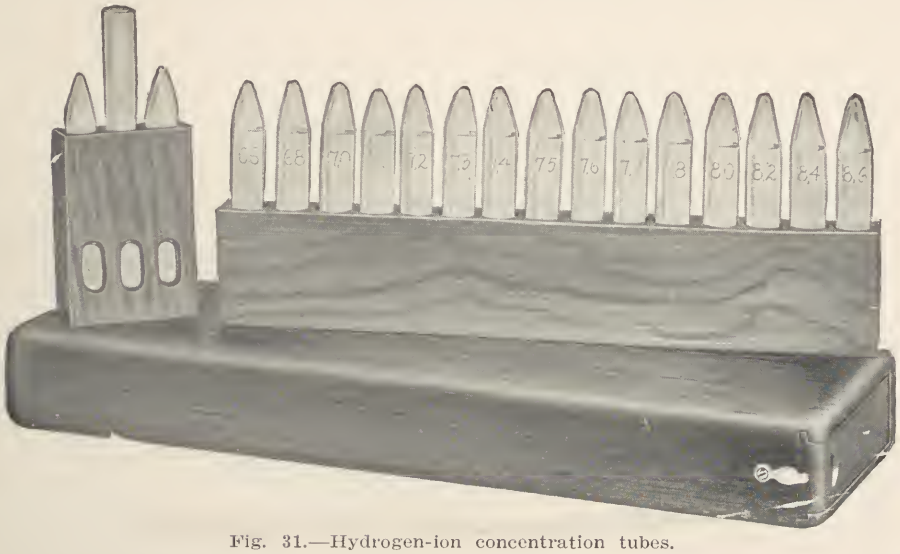

Fig. 31.—Hydrogen-ion concentration tubes.

Preparation of Sacks.—Sacks of celloidin or Anthony's negative cotton, are used for dialysis. They are made as follows: One ounce of celloidin is dissolved in 500 c.c. of a mixture of equal parts of alcohol and ether. The solution is allowed to stand for a week to permit impurities to settle.

A test tube about 50 mm. long and 6 mm. in diameter is filled with the celloidin solution, and slowly poured out with a rotary motion. This leaves an even coating on the inner surface of the tube. After draining and drying for ten minutes the tube is filled with cold water, the upper edge of the celloidin sack is loosened and water poured between it and the tube, and the sack removed from the test tube. Several of these sacks may be made at one time and preserved by immersing them in water.

The salt indicator solution is made as follows: Eight gm. of chemically pure sodium chloride is dissolved in distilled water, 220 c.c. of 0.01 per cent solution of phenolsulphonephthalein is added and the whole made up to one liter with distilled water. Jena glassware is used.

This solution should have a pH of 7.0, and if it does not prove so on comparison with the standard indicator tubes, should be titrated to this point with weak alkali or acid.

Procedure.—The celloidin sacks to be used are immersed in some of the salt-indicator solution. A few c.c. of blood are withdrawn with a needle from one of the patient's veins, care being taken that the blood does not hemolyze. The blood is centrifuged at once to separate the serum. One-half c.c. of the serum is measured into one of the celloidin sacks, and the sack suspended in a larger test tube containing 2 c.c. of a salt-indicator solution. The fluid level must be at least as high on the outside as on the inside of the sack. At the end of 7 minutes the sack is removed. The dialysate is transferred to a tube of the same diameter as the standard indicator tubes. A rapid current of air is blown through the solution to remove the carbon dioxide. An atomizer bulb and a small glass tube is satisfactory for this purpose. After

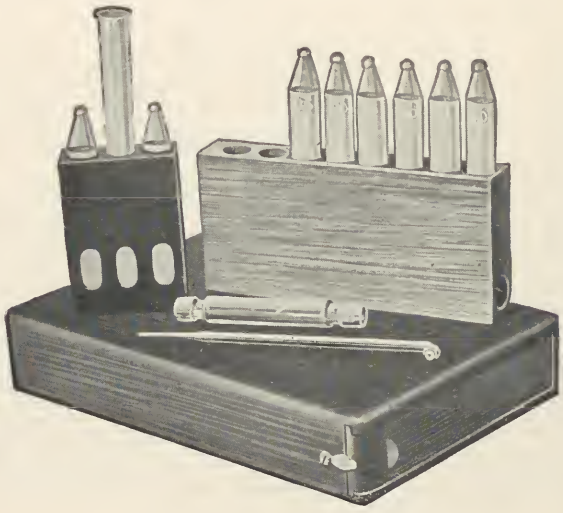

Fig. 32.—Alveolar air tubes.

three minutes the color of the solution is compared with that of the standard tubes. The readings are given on the tubes in terms of RpH (Fig. 30). The normal values are 8.4 to 8.55 corresponding to an alveolar CO_2 tension of 35 to 45 mm. Values from 8.0 to 8.3, corresponding to an alveolar CO_2 of 28 to 35 mm. indicate moderate acidosis. Values below 7.7 indicate immediate danger of coma. The above values hold good for adults and older children. Infants give lower readings. They may show an RpH of 8.3 and yet have no evidence of acidosis.

The hydrogen-ion concentration outfit (Fig. 31) is sometimes used in clinical work to determine an advanced state of acidosis.

Table VIII on page 71, from Palmer and Van Slyke, may be utilized clinically in the treatment of acidosis.

Alveolar Air Tension.—Normally the alveolar air tension varies between 40 and 45 millimeters of mercury. In acidosis less CO_2 is expired by the

Table VIII

WEIGHT OF INDIVIDUAL		SODIUM BICARBONATE NECESSARY TO RAISE PLASMA CO_2 VOLUME PER CENT
kg.	lb.	gm.
19	42	0.5
38	84	1.0
57	126	1.5
76	168	2.0
95	210	2.5

lungs and the alveolar air tension is therefore lowered. In severe cases of acidosis the alveolar air tension falls as low as 20 mm. of mercury. The determination of alveolar air is thus one of the methods of determining the presence of acidosis.

Technic.—A set of standard color tubes is used. The tubes may be obtained on the market.

A standard bicarbonate solution is made either by weighing out 0.530 grams of desiccated sodium carbonate, or by measuring accurately 100 c.c. of tenth normal sodium hydroxide into a liter flask. Two hundred c.c. of 0.01 per cent phenolsulphonephthalein are added and the whole made up to the mark with distilled water. The flask containing the solution should be kept corked and paraffined.

A rubber bag of about 1500 c.c. capacity is used to collect the alveolar air. A basket ball bladder answers the purpose. For infants a bag of 500 c.c. capacity and a small rubber funnel to take the place of a mask are used. The bag is half filled with air with an atomizer bulb, and the patient breathes back and forth into the bag, 4 times in 20 seconds. The bag is then closed by a pinchcock.

Two or three c.c. of the standard bicarbonate solution are now placed in a small test tube similar to those containing the standard color solutions. Air from the bag is then blown through the solution by a glass tube drawn out to a small bore, until the solution is saturated. When no further color change takes place the saturation is complete. The tube is stoppered and the color at once compared with the standard color tubes. The numbers on the tubes (Fig. 32) give the carbon dioxide tension, in mm. of mercury. The alkali reserve of the blood may be obtained by multiplying the alveolar air tension by 0.7.

CHAPTER VI

EXAMINATION OF CEREBROSPINAL FLUID

Cerebrospinal fluid may be removed from the body either for diagnostic or for therapeutic purposes. Among the most important diagnostic indications should be considered symptoms of increased intracranial pressure, such as convulsion or coma; symptoms of meningeal inflammation or irritation, such as rigidity of the neck or Kernig's sign and symptoms of neurosyphilis. There is a diversity of opinion as to the advisability or even permissibility of removing cerebrospinal fluid in cases of suspected brain tumor. With sufficient care, however, cerebrospinal fluid may be removed in cases of brain tumor.

For the purpose of treatment, cerebrospinal fluid may be removed in cases where relief of intracranial pressure is indicated such as in all types

Indications for Removal of Fluid.—

For Diagnosis
- Suspicious meningitis
- Suspicious poliomyelitis
- Hemorrhage of the brain
- Neurosyphilis
- Coma
- Convulsions

For Treatment
- (a) Relief of intracranial pressure
  - Meningitis
  - Meningism
  - Poliomyelitis
  - Encephalitis
  - Hemorrhage of the brain
  - Delirium
  - Convulsions
- (b) Intraspinal injections
  - 1. Serum Treatment
    - Antimeningococcus
    - Pneumococcus Type I
    - Influenza
    - Poliomyelitis
    - Tetanus antitoxin
    - Horse serum
  - 2. Chemicals
    - Neosalvarsan
    - Mercury
    - Optochin
    - Magnesium sulphate
    - Novocain
    - Adrenalin
- (c) Miscellaneous
  - General edema
  - Diabetes insipidus

of meningitis or meningism and in cases where intraspinal or intraventricular injection is indicated, especially where meningococcus serum is to be given. There is a diversity of opinion as to whether or not cerebrospinal fluid be removed in cases of brain hemorrhage for therapeutic purposes. Some claim that removal of cerebrospinal fluid will lower the intracranial pressure and thus relieve the symptoms. Others claim that removal of cerebrospinal fluid may start a new hemorrhage by removing the clot. I believe that in aged individuals with arteriosclerosis there is some justification in the argument against removal of cerebrospinal fluid in cases of hemorrhage. In the newly born, however, removal of fluid often relieves the symptoms of intracranial pressure and is therefore indicated in selected cases.

METHODS OF REMOVING FLUID

One of three routes may be used to withdraw cerebrospinal fluid from a human being: (1) Spinal, (2) Ventricular, (3) Cistern or occipito-atloid. Of these three routes, the spinal is the simplest and most advisable. Next to it is the ventricular route, and last and most dangerous, is the cistern or occipito-atloid. Whenever possible, therefore, a spinal puncture should be done for the withdrawal of the cerebrospinal fluid from the body. Because of its importance, spinal puncture will be discussed first.

Technic of Spinal Puncture.—The needle for spinal puncture in children should be of a wide lumen, otherwise, the thick fluid often encountered in suppurative meningitis may occlude the opening. The needle used in puncturing the newly born should be ½ to ¾ of an inch shorter than the standard needle. The lumen, however, should be just as large as in the ordinary needle, as newly born often suffer from suppurative meningitis, and unless the needle is sufficiently wide, the pus may clog up the opening. There are several makes of spinal puncture needles on the market, most of them being 2½ to 3 inches in length and 0.2 to 0.6 mm. in thickness. Each needle is fitted with a stylet. There are also needles with stopcocks made to fit various manometers used for measuring the pressure of the fluid.

The test tubes for collecting the fluid should be small, sterile and chemically clean, otherwise the interpretation of the results obtained by examination may be misleading.

The preparation for spinal puncture should be the same as for any other operation. The needle should be boiled, the patient's skin should be washed with alcohol and iodine and the physician should scrub his hands and wear gloves during the procedure.

The puncture should be done with the patient on a table or cart, a bed not being steady enough. All punctures should be performed with the patient lying down, preferably on his right side. The patient's body should be bent, so as to separate the intravertebral spaces. The needle should be introduced directly into the median line in very young children, and a few millimeters away from the median line in older children. The space of choice for the introduction of the needle is between the second and third interspace, although one may go one space higher without fear. A horizontal

line drawn at the level of the crest of the ilium will usually strike the desired interspace.

After puncturing the skin, the needle should be directed forward and slightly upward, until a snap is felt, which usually indicates the puncturing of the dura. The stylet should then be removed slowly, so that only a few drops or at least a small stream comes out at first. A sudden complete removal of the stylet may bring forth a gush of fluid which would be undesirable in case of brain tumor, as it may cause a prolapse of the brain into the foramen magnum. The fluid, if obtainable, should be emptied into the test

Fig. 33.—Photograph showing ventricular puncture in infant by way of the anterior fontanelle. Dark circular spot shows needle in position. (Front view.)

tubes. In case a manometer is used, the stopcock should be turned to prevent the escape of fluid, the manometer attached, and the pressure measured before the fluid is allowed to run into the test tubes.

It has been found best to use three or four test tubes for the collection of the fluid, so that if the patient moves around during the latter stage of the puncture and the fluid becomes bloody, as often happens, the first or second tube could still be used for examination. After the desired amount of fluid has been obtained, the stylet should be reintroduced into the needle, and the needle pulled out from the patient's body. The wound should be closed with collodion.

Rest in bed should be insisted upon after every spinal puncture. While

it does not always prevent headache, if it does occur, the headache is not so severe as when the patient is up and around.

Failures in Spinal Puncture.—The two most important and most frequent failures are (1) inability to obtain fluid and (2) obtaining bloody fluid. While there are cases where there is very little or no fluid in the spinal canal, such as in marked atrophy of the spinal cord and in obstruction of the canal by a tumor, the average dry tap is due to the fact that the operator has not reached the spinal canal or has passed beyond it. In very fleshy children it is hard to feel the intervertebral spaces. Failure to obtain fluid is therefore more frequent in fat than in slender children.

In deformities of the spine, due to rickets or tuberculosis, it may be impossible to reach the spinal canal. In such cases, it may be necessary either to introduce the needle obliquely to reach the spinal canal, or, to resort to a ventricular puncture.

The obtaining of bloody fluid is possibly the most frequent mishap in spinal puncture. It happens to both the inexperienced and the experienced. The blood is due to injury produced to the plexus of veins in the canal. Once blood is obtained the fluid cannot be used for cell count or any chemical tests. It may, however, still be used for bacteriologic purposes. A Wassermann test may be performed on bloody fluid, although at times the blood makes the fluid anticomplementary. If clear fluid is desired for examination, no new puncture should be done for several days after blood has been obtained, as it takes three days for blood to be absorbed from the spinal canal. However, when it is necessary to give serum intraspinally, blood obtained on spinal puncture does not counterindicate the procedure.

Death after spinal puncture has been reported in the literature. Death in those cases may have been due to the withdrawal of too great a quantity of fluid, thereby allowing parts of the brain to descend to the foramen magnum and become obstructed there. It is also possible that the punctures in those cases were performed with the patient in the sitting position, which in itself may be responsible for a herniation of the brain. With the exception of a tumor of the cerebellum, no condition counterindicates spinal puncture, the possibility of death by puncture being minimal. I have done many punctures in cases of brain tumor without a single complicating death.

Shock is not an infrequent complication. A hypodermic injection of atropine usually relieves it.

Injury to the aorta by spinal puncture has been reported, but is very uncommon. Breaking off the needle is not an infrequent complication in adults, but seldom occurs in children.

Headache after a spinal puncture is a common occurrence, but usually disappears in a day or two, especially if the patient stays in bed.

Radiating pain in the lower extremities takes place if filaments of nerves have been touched in the spinal canal by the needle. The pain, however, does not last long.

Edema of the skin in the lumbar region has been observed after repeated punctures. The edema, however, subsides in a few days.

Ventricular Puncture.—*Indications.*—Ventricular puncture in infants is not associated with any danger, yet it should not be performed unless lumbar puncture has failed repeatedly. Where the latter has failed either for the purpose of the removal of cerebrospinal fluid or for the introduction of serum, ventricular puncture should be performed without hesitation.

Technic.—The hair around the anterior fontanelle should be shaved and alcohol and iodine applied. The operation proper varies with the age of the child. In infants the operation is very simple. In older children, in whom the anterior fontanelle is closed, the procedure is complicated and requires many surgical instruments.

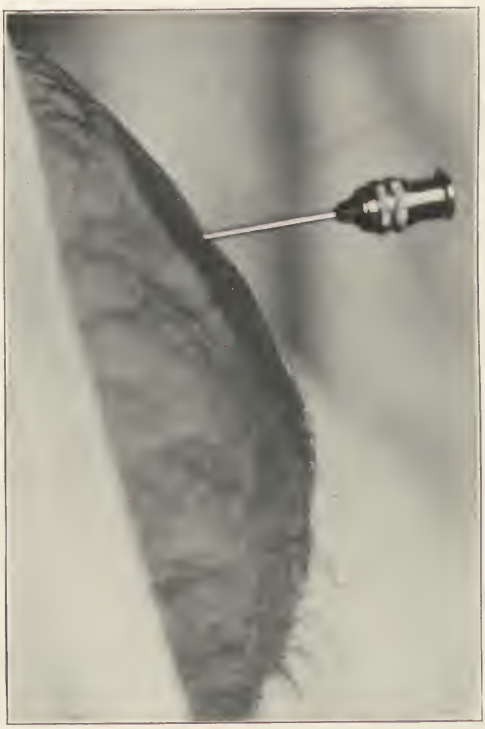

Fig. 34.—Photograph showing ventricular puncture in infant. (Side view.)

The technic in infants is as follows: The patient is placed in the recumbent posture on a table, with the head at the end of the table. The head, shaved and washed with alcohol, is steadied by an assistant. A regular spinal puncture needle is now introduced ½ to 1 centimeter to one side of the midline of the anterior fontanelle. The needle is directed forward and to a depth of 1 to 1½ inches until the lateral ventricle is reached. In hydrocephalic children ½ inch suffices. The stylet is now removed and fluid is collected into one or more test tubes (Figs. 33 and 34). If no fluid is obtained the needle should be withdrawn and reintroduced, but should not be manipulated unduly while in the brain, in order to avoid damage to the brain tissue. If no fluid is obtained by the fontanelle route, and if the bones of

the skull are still separated, the needle may be introduced between the frontal and parietal bone 1 to 1½ inches deep.

CISTERN PUNCTURE

If both the spinal and ventricular routes have failed, cistern puncture may be employed for the purpose of obtaining cerebrospinal fluid, or for the introduction of serum. The technic, originally described by Wegeforth, Ayers and Easick is as follows:

A spinal puncture needle is introduced into the midline of the back of the neck just above the spine of the axis. The glabella and the upper edge of the external auditory meatus may be used as a landmark for the insertion of the needle, for a plane passed through them to the back of the neck will pass also through the occipito-atloid ligament. In thin persons a deep depression can be palpated between the occipital protuberance and the spine of the axis. This depression serves as another landmark. The needle is introduced at a depth of 3 to 5 cm., the average being 4 cm.

The preparation for the puncture and the collection of the fluid are the same as for spinal or ventricular punctures.

METHODS OF EXAMINATION

The fluid should be examined for physical, chemical, physiochemical, bacteriologic and immunologic alteration.

Amount.—Normally, only five to ten c.c. of cerebrospinal fluid can be removed by spinal puncture. In nearly all pathologic cases, the amount of cerebrospinal fluid is increased. In acute infections, whether due to inflammation or only to irritation of the meninges, the amount is greatly increased and one can often remove as high as 30 to 40 c.c. in one sitting. In chronic inflammation of the meninges or of the brain, the amount is also increased. Only in tumor of the cord and in some cases of obstructive hydrocephalus is the amount decreased. Seldom does one see a case where no fluid at all can be removed from the spinal canal and which is not due to faulty technic. Such may be the case in tumor of the cord or in spina bifida.

Pressure.—Normally, the pressure of the cerebrospinal fluid in children, when measured as it escapes from the canal, is 40 to 90 mm. of water high in the recumbent posture. In acute infections or irritations of the meninges the pressure may go up as high as 300 or 400 mm. of water. In cases of obstruction of the cord, the pressure may be lessened.

Color.—Normal cerebrospinal fluid is colorless. Many pathologic conditions do not change the color of the fluid, such for instance is the case in encephalitis, poliomyelitis and tuberculous meningitis. In some conditions, however, the fluid changes color. In all suppurative meningitis for instance, the fluid is turbid. In jaundice, the fluid is greenish-yellow; in tumors of the cord, the fluid is deep yellow, and is known as xanthochromia. In hemorrhage of the brain, the fluid is bright or dark red, in the early stages, but may be colorless after a few weeks.

Sediment or Pellicle.—Normal fluid forms no sediment when allowed to stand. In meningitis, however, a pellicle or sediment usually forms in the fluid on standing. In suppurative forms of meningitis, the pellicle forms within a few minutes. In tuberculous meningitis, it usually takes 12 to 24 hours for the sediment to form.

Globulin.—Normal fluid contains only a small amount of protein. All acute and chronic inflammation of the meninges increases the protein in the fluid.

The following are the most simple tests for the determination of the increase of globulin.

Pandy.—One drop of cerebrospinal fluid is added to one or two c.c. of a concentrated solution of carbolic acid (1 part phenol crystals to 15 parts of water). A bluish white cloud forms in the test tube if globulin is present in excess of normal. When mixed, the solution becomes turbid. If the globulin is not increased the solution remains clear.

Ross-Jones.—Two-tenths to 0.5 c.c. of a saturated ammonium sulphate solution is poured into a small test tube. An equal amount of cerebrospinal fluid is floated upon it by running it down the side of a slanted tube. A white ring develops in a few seconds to 2 or 3 minutes at the point of contact, if the globulin in the fluid is increased.

Noguchi.—Two-tenths c.c. of cerebrospinal fluid is poured into a small test tube, and 0.5 c.c. of a butyric acid solution (5 c.c. of butyric acid to 45 c.c. physiologic salt solution) is added to the fluid. The mixture is boiled for a few seconds and 0.1 c.c. of NaOH (normal 4 per cent aqueous solution) is added to it and it is again boiled for a few seconds. If the globulin in the fluid is increased, a fine or coarsely granular, flocculent deposit forms in from one to ten minutes. If no coarse flocculi appear within two hours, even if a slight opalescence is present, the globulin is not increased.

Sugar.—Normally, cerebrospinal fluid contains 0.08 to 0.1 per cent of sugar. In suppurative meningitis, especially in the meningococcus form, the sugar is either decreased or absent from the fluid. An absence of sugar in the fluid, therefore indicates meningitis. Although not very accurate, Fehling's reduction test will answer the purpose.

The Lange Gold Chloride Test.—The gold chloride test of Lange may be considered of great value in the diagnosis of pathological conditions of the cerebrospinal fluid. Normally, the fluid does not change the ruby red color of the original gold chloride solution. In luetic infections of the central nervous system, one or more of the first five tubes in the series, is changed in various degrees, from violet to colorless. In tuberculous meningitis the fifth, sixth and seventh tubes are usually affected. In suppurative meningitis one or more of the last five tubes change colors. (Figs. 35 and 36.)

The technic of making up the gold chloride solution is rather difficult, some solutions producing color changes even with normal fluids, and others producing no changes even with distinctly luetic fluids. Care must be taken to see that the solution is transparent, of neutral reaction, and that it is precipitated by 1.7 c.c. of 1 per cent NaCl solution in one hour. There are

Fig. 35.—Lange gold chloride reaction in a case of tuberculous meningitis.

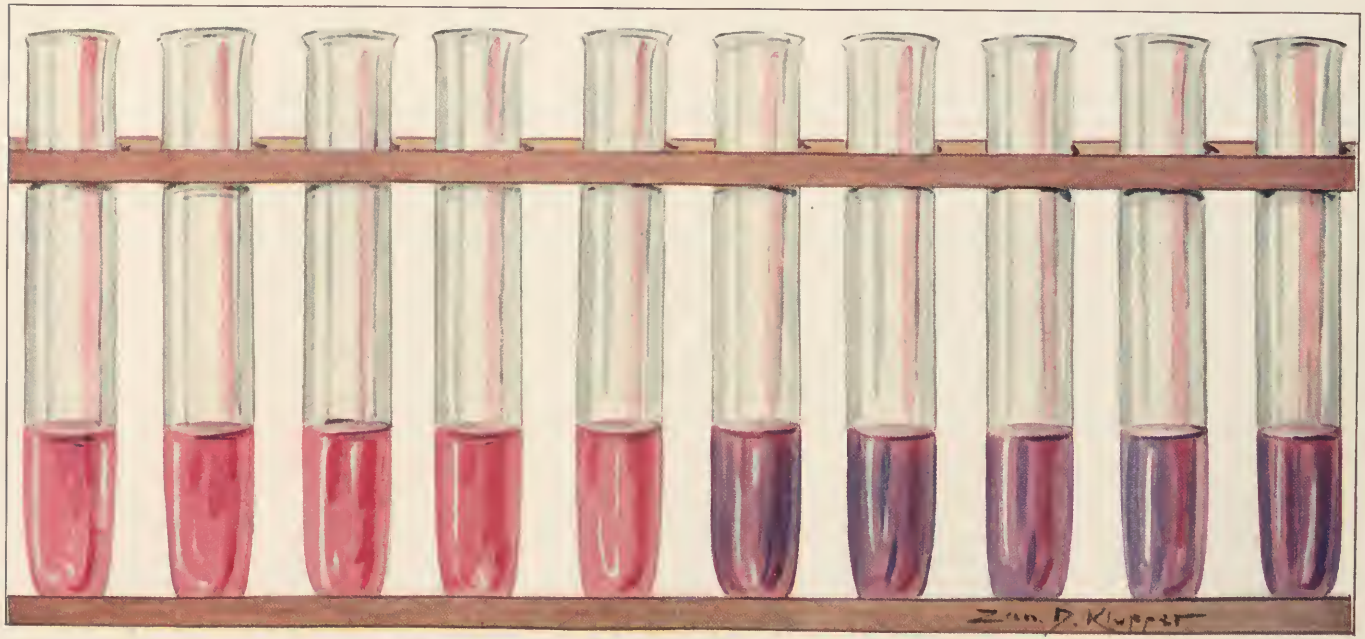

Fig. 36.—Lange gold chloride reaction in a case of meningococcus meningitis.

several modifications of the original Lange technic of preparing colloidal gold solution, but we believe the following technic to be very satisfactory.

The method is as follows: To 1000 c.c. of doubly distilled water, 10 c.c. of a 1 per cent gold chloride solution and 7 c.c. of a 2 per cent solution of potassium carbonate are added. The mixture is heated to 90° C., stirred vigorously and 5 c.c. of a 1 per cent formaldehyde solution is added. The solution should at once assume a red color.

The method of testing cerebrospinal fluid with the above solution is as follows: 0.2 c.c. of cerebrospinal fluid is introduced into the first one of a series of 10 test tubes containing 1 c.c. of 0.4 per cent sodium chloride. Ten dilutions of the cerebrospinal fluid are now made, by taking 1 c.c. of the

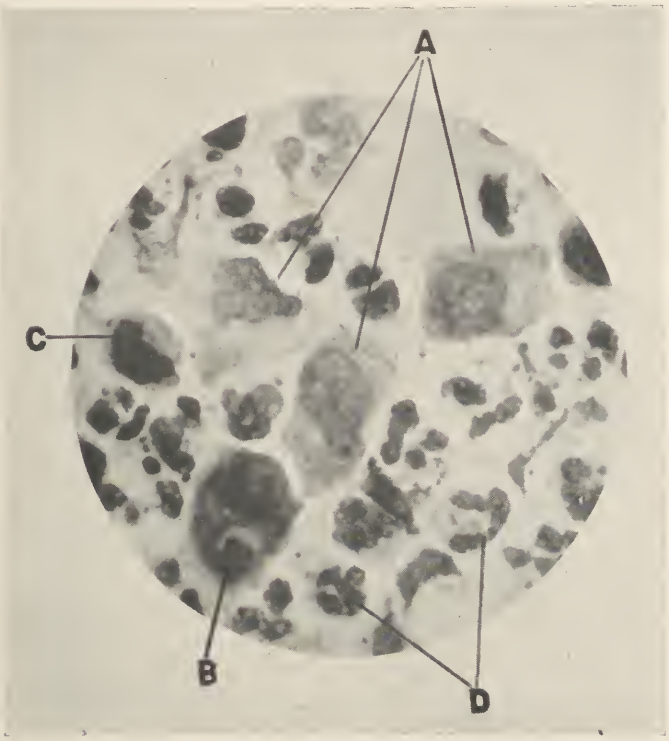

Fig. 37.—Photomicrograph showing types of cells in pathologic cerebrospinal fluid. x1000. *A*, endothelial cells. *B*, endothelial cell which has engulfed a polymorphonuclear leucocyte. *C*, large mononuclear cell. *D*, polymorphonuclear leucocytes.

first tube and transferring to the second, then 1 c.c. of the second and transferring to the third, etc., the dilutions thus ranging from 1 to 10 to 1 to 5120. An eleventh tube containing 1 c.c. of 0.4 per cent sodium chloride without cerebrospinal fluid may be used as a control. It is also advisable to run another gold chloride test on a fluid known to be normal. To each tube 5 c.c. of the colloidal gold reagent (1 per cent solution of gold chloride, 2 per cent solution of K_2CO_3, 1 per cent solution of formalin) is added and the color change observed.

Cellular Elements.—Normal fluid contains one to six cells per cubic mm. all of which are small lymphocytes. In infections of the meninges and

Table IX

Cerebrospinal Fluid Findings in Various Conditions

CONDITION	ORGANISM	COLOR	AMOUNT	PRESSURE	SEDIMENT	CELLS	PERMANGANATE INDEX	GLOBULIN INCREASE	SUGAR	WASSERMANN	LANGE	SPECIAL TESTS
			(Number of c.c. easily removed)			(Number per c. mm. and type)						
Normal	None	Clear	5-10	90 mm. of water in child. 150 mm. in adult	None	1-6 Small lymphocytes	Less than 2	No	0.05-0.1%	Negative	Negative	
Uremia	None	Clear	Normal or Increased	Increased	None	Normal	2 or over	slight or marked	Normal	Negative	Negative	Urea may be increased. Chlorides occasionally increased.
Diabetes	None	Clear	Normal	Normal	None	Normal	2 or over	No	Above 0.1%	Negative	Negative	Acetone may be present.
Skull fracture(without meningeal hemorrhage)	None	Clear	Normal or greatly increased	Normal or Increased	None	Normal	Less than 2	No	Normal	Negative	Negative	
Meningeal hemorrhage (a) bloody	None	Bloody	Increased	Increased	Bloody	Many red and white	Above 2	Yes	Normal	Negative	Negative	Cholesterol present. Serum albumin in large quantities.
(b) clear (Old standing)	None	Clear	Normal or Increased	Increased	None	5-10 small lymphocytes	2 or over	Slight	Normal	Negative	Negative	Cholesterol present. Serum albumin may be present in large quantities.
Lateral sinus Thrombosis	None	Clear	Normal or Increased	Increased	None	Normal	Normal	No	Normal	Negative	Negative	
Brain tumor	None	Clear	10-15	Slightly increased	None	10-15 Small or large lymphocytes	Normal	Slight	Normal	Negative	Occasionally 044230-0000	Inhibition of hemolysis described by Hauptmann. Increased cholesterol.

TABLE IX—CONTINUED

CEREBROSPINAL FLUID FINDINGS IN VARIOUS CONDITIONS

CONDITION	ORGANISM	COLOR	AMOUNT	PRESSURE	SEDIMENT	CELLS	PERMANGANATE INDEX	GLOBULIN INCREASE	SUGAR	WASSERMANN	LANGE	SPECIAL TESTS
Brain abscess (a) not ruptured	None	Clear	Slightly increased	Slightly increased	None	10-15 Small lymphocytes Occasionally large lymphocytes	Normal	Slight	Normal	Negative	Occasionally 044430-0000	
(b) ruptured	Any organism	Turbid	Increased	Increased	Yes	Several thousand polymorphonuclear leucocytes	Above 2	Marked	Normal	Negative	000000-4444	
Spinal cord tumor	None	Yellow (Xanthochromia)	Decreased	Decreased	Coagulates spontaneously	None or 1-2	Above 2	Marked	Normal	Negative		
Syphilis of central nervous system												
(a) Gen. Paresis	None	Clear	10-40	Increased	None; Occasionally small flocculi	40-200 Small lymphocytes	Normal	Marked	Normal	Positive	555550-0000 (Paretic curve)	
(b) Cerebrospinal syphilis	None	Clear	Increased 15-30	Increased	None	100-20 Small lymphocytes	Normal	Yes	Normal	Positive	005555-0000	
(c) Tabes dorsalis	None	Clear	Increased	Increased	None	60-80 Small lymphocytes	Normal	Yes	Normal	Positive	005550-0000 (Tabetic curve)	

TABLE IX—CONTINUED

CEREBROSPINAL FLUID FINDINGS IN VARIOUS CONDITIONS

CONDITION	ORGANISM	COLOR	AMOUNT	PRESSURE	SEDIMENT	CELLS	PERMANGANATE INDEX	GLOBULIN INCREASE	SUGAR	WASSERMANN	LANGE	SPECIAL TESTS
(d) Juvenile paresis	None	Clear	Increased	Increased	None	40-80 Small lymphocytes	Normal	Yes	Normal	Positive	555550-0000	
Meningism	None	Clear	Increased	Increased	None	Normal or slightly increased	Normal	No or slight	Normal	Negative	Negative	
Epidemic encephalitis	Minute filterable virus described by some authors	Clear	10-30	Increased	None	10-20 Small mononuclear	Normal	Slight	Normal	Negative	Negative	
Anterior poliomyelitis	Micrococcus described by some authors	Clear	Increased	Increased	None	10-100 polymorphonuclear very early, mononuclear after second day	Normal	Yes	Normal	Negative	Luetic zone early. Meningitic zone later	
Tuberculous meningitis	Tubercle bacilli	Clear or slightly opalescent	Increased	Increased	Fine pellicle	30-400 Mononuclear	Above 2	Yes	Normal or less	Negative	Between luetic and meningitic zones. (000023-3000)	(1) Cataphoresis to the anode. (2) Sulphosalicylic precipitate 3-6 mm. Bichloride of mercury 6-20 mm. (3) Guinea pig inoculation shows tubercles

TABLE IX—CONTINUED

CEREBROSPINAL FLUID FINDINGS IN VARIOUS CONDITIONS

CONDITION	ORGANISM	COLOR	AMOUNT	PRESSURE	SEDIMENT	CELLS	PERMANGANATE INDEX	GLOBULIN INCREASE	SUGAR	WASSERMANN	LANGE	SPECIAL TESTS
Meningococcus meningitis	Meningococcus	Turbid	Increased	Markedly Increased	Thick, Varying with stage of disease	50-8000; 95% Poly's; Endothelial cells present	Above 3	Marked	Absent or greatly diminished	Negative	Meningitic zone 00000-45555	(1) Cataphoresis to the cathode. (2) Agglutination of bacteria by specific serum. (3) Precipitation of fluid with antimen. serum. (4) Sulphosalicylic acid 7-20 mm., Bichloride 5-6 mm.
Pneumococcus meningitis	Pneumococcus	Turbid	Increased	Increased	Present	50-8000 98% Poly's	Above 2	Yes	Normal or diminished	Negative	Meningitic zone	Agglutination. Sulphosalicylic 7-20 mm.; Bichloride 5-6 mm.
Streptococcus meningitis	Streptococcus	Turbid	Increased	Increased	Yes	50-1000 98% Poly's	Above 2	Yes	Normal or diminished	Negative	Meningitic zone	Sulphosalicylic 7-20 mm. Bichloride 5-6 mm.
Influenza meningitis	Influenza bacillus	Turbid	Increased	Increased	Yes	50-1000 98% Poly's Occasionally 50% lymphocytes	Above 2	Yes	Normal or diminished	Negative	Meningitic zone	Sulphosalicylic 7-20 mm. Bichloride 5-6 mm. Indol test described.
Other Meningitis	Specific organism	Turbid	Increased	Increased	Heavy	50-1000 98% Poly's	Above 2	Increased	Normal or diminished	Negative	Meningitic zone	

occasionally in irritation of the meninges, the number of cells are increased. The more acute the infection, the greater the number of cells.

The type of cell differs with the pathologic condition. In tuberculous meningitis, in certain stages of poliomyelitis, the cells are mainly lymphocytes. On the other hand, the cells in all suppurative meningitis are mainly polymorphonuclear in type. In addition to the polymorphonuclear cells, however, there are also endothelial cells. This type of cell is particularly predominant in meningococcus meningitis. The same is true with the phagocytes which are present in large number in meningococcus meningitis. In tumor of the brain large lymphocytes may be present in considerable number. (Fig. 37.)

Method of Counting Cells.—A special counting apparatus has been devised by Fuchs and Rosenthal for the counting of cells in cerebrospinal fluid. This chamber is 16 mm. square instead of 9 mm. as in the blood counting chamber, and is 0.2 mm. deep instead of 0.1 mm., as in the blood counting chamber. This chamber, therefore, allows of a smaller error than the blood chamber. In using this chamber the cerebrospinal fluid is drawn up to mark 1 in the leucocyte pipette and the diluting fluid to mark 11. The cells in the whole chamber are counted and the resulting number is multiplied by 11 and divided by 32. As a diluent for the fluid, a solution of methyl violet (methyl violet 0.2 gm. glacial acetic 5 c.c. and water to 100 c.c.) has been found very useful, although ordinary 2 to 3 per cent acetic acid will do to destroy the red cells in the fluid. The Fuchs-Rosenthal chamber, while more accurate, is not absolutely necessary, an ordinary blood counting chamber will suffice. The technic is as follows:

The methyl violet or other diluent is drawn up to mark 1 in the pipette and the cerebrospinal fluid to mark 11. In order to obtain the number of cells in one cubic millimeter of undiluted fluid, the result obtained is multiplied by 11 and divided by 9. A rougher yet fairly accurate clinical method is to draw up glacial acetic acid in the pipette and blow it out, and then draw up the cerebrospinal fluid. This is sufficient to dissolve the red blood cells. No allowance has to be made, then, for diluting fluid. The cells must be counted immediately after withdrawal from the body, as they undergo autolysis on standing. If it is impossible to count cells in the fluid immediately after its withdrawal from the body, the cells may be preserved by the addition of 2 to 3 drops of a 3 per cent acetic acid solution to 5 c.c. of cerebrospinal fluid. The subsequent count will not be very accurate, but will give a good idea of the number of cells in the fluid.

Differential Cell Count.—When the fluid is turbid as in suppurative meningitis, a differential cell count may be made on an uncentrifuged fluid. If the fluid is clear or only slightly opalescent, it is best to centrifuge the fluid for from fifteen to thirty minutes at about 1500 revolutions per minute. It should be stained with Wright's stain or methylene blue.

Bacteriological Examination.—In suppurative meningitis where the cerebrospinal fluid is thick, a slide may be prepared from the uncentrifuged fluid. When the fluid is clear, it should be centrifuged for several minutes,

and the sediment examined. Where suppurative organisms are suspected, it is best to stain with both methyl blue and Gram stain. When tubercle bacilli are searched for, the fluid should be allowed to centrifuge at high speed for thirty to sixty minutes and stained by the Ziehl-Neelsen method. If a pellicle is found in the fluid, the pellicle should be stained for tubercle bacilli.

Culture Media.—Several drops to 1 c.c. of cerebrospinal fluid or its sediment are planted on a culture media, the kind of media depending on the bacteria looked for. In cases suspicious of poliomyelitis anaerobic cultures should be made, as it is claimed that in this way the organism will be found in culture. In most other cases blood agar is the best culture medium. The culture is examined after 24 and 48 hours incubation.

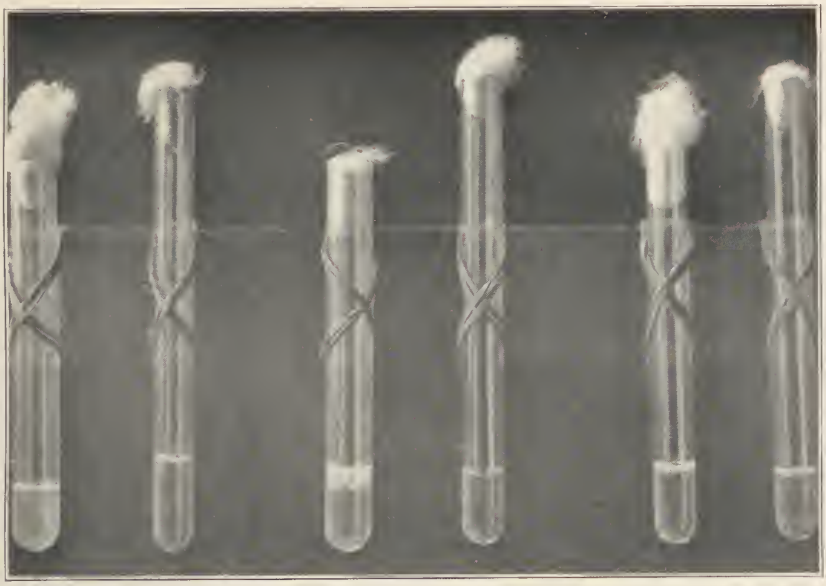

Fig. 38.—Photograph showing agglutination of meningococci by the macroscopic method.

A. Emulsion of meningococci + 1:10 dilution of antimeningococcus serum.
B. Control of emulsion of meningococci + salt solution.
C. Emulsion of meningococci + 1:160 dilution of antimeningococcus serum.
D. Control.
E. Emulsion of meningococci + 1:640 dilution of antimeningococcus serum.
F. Control.

Agglutination.—In order to make certain that the antimeningococcus serum used in treating a given case of meningococcus meningitis is specific for the particular strain of meningococcus in question, the bacteria obtained by culturing the cerebrospinal fluid of the patient should be tested by the antimeningococcus serum used for treatment. Unless the bacteria are agglutinated by the serum, the given serum is not to be used in the treatment, and a serum must be found that will agglutinate this particular strain of meningococcus in question.

Technic.—Two methods have been described for this purpose: the macroscopic and the microscopic.

The macroscopic method is carried out by washing down the growth of the culture in question with two or three c.c. of an 0.8 per cent sterile salt solution, and adding 0.2 c.c. of this emulsion to various dilutions, (1:10, 1:20, 1:40, etc., to 1:2000) of antimeningococcus serum, and incubating it for 15 to 20 hours. If the bacteria in the culture is meningococcus, a flocculent precipitate will appear in the tubes, containing as high a dilution as 1:2000, or even higher. If it is not meningococcus, it will either not agglutinate at all, or it will agglutinate only in very low dilutions, such as 1:50, or 1:10 (Fig. 38).

The microscopic method consists of using one drop of antimeningococcus serum, one drop of whole human blood in a sodium citrate solution (1 drop of blood to 2 per cent sodium citrate in salt solution), and one drop of a

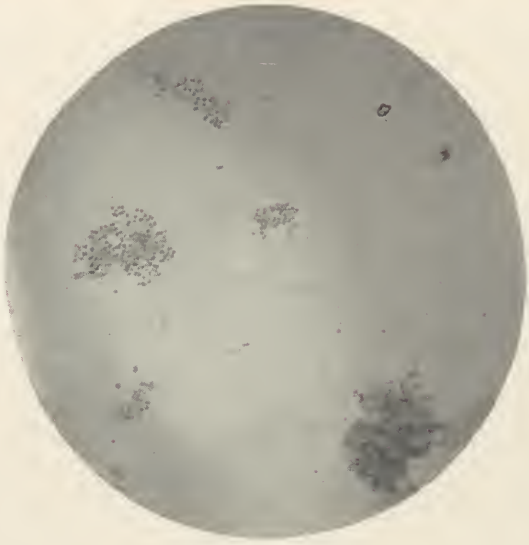

Fig. 39.—Agglutination of meningococci by the microscopic method. (Tunicliff)

suspension of the organism to be tested. This is mixed in a pipette, heated for 20 minutes, spread on a slide, stained and examined under the microscope. If the bacterium is meningococcus, a distinct clumping will be seen under the microscope. This should be controlled by a suspension of meningococcus with normal horse serum, or by a suspension of some other bacteria with antimeningococcus serum. (Fig. 39.)

Guinea Pig Inoculation.—Five to 10 c.c. of cerebrospinal fluid is injected subcutaneously into the anterior abdominal wall of a normal guinea pig. The needle should be pointed downward and laterally toward the inguinal region. Six weeks later, or sooner in case the guinea pig dies, an autopsy should be performed and the inguinal and mesenteric lymph nodes, as well as the liver and spleen, should be examined. If tubercles are found, the patient from whom the cerebrospinal fluid was obtained, suffered from tuberculous meningitis.

Wassermann Reaction.—While there are diseases other than syphilis, such as leprosy or sleeping sickness, that may give a positive Wassermann reaction, the test is sufficiently reliable to consider the patient syphilitic when the reaction is positive.

The technic of the Wassermann test on cerebrospinal fluid is the same as that on blood, except that the cerebrospinal fluid does not have to be heated as in the case of blood serum; and the amount of cerebrospinal fluid taken for each test must be greater than the amount of blood used.

Usually 0.2 c.c. of cerebrospinal fluid is taken for each of the tubes set up, varying the amount of antigen added to the tubes. As a control 0.4 c.c. of cerebrospinal fluid without antigen is used. Schottmüller advises the use of different amounts of cerebrospinal fluid in each of the test tubes. This gives a more or less quantitative result as to the degree of positiveness of the fluid.

CHAPTER VII

EXAMINATION OF URINE AND STOOL

Urine

Collection of Urine.—From children over two years of age, urine can be obtained by having the child urinate into a vessel. From male infants urine may be collected by attaching a small bottle or test tube or a portion of a rubber glove over the genital organ, fastening it in place by means of adhesive plaster attached to the pubic area (Fig. 40). It may also be collected by tying a strap or roller bandage around the bottle and tying the other end of the roller bandage around the abdomen, as suggested by Schick (Fig. 42).

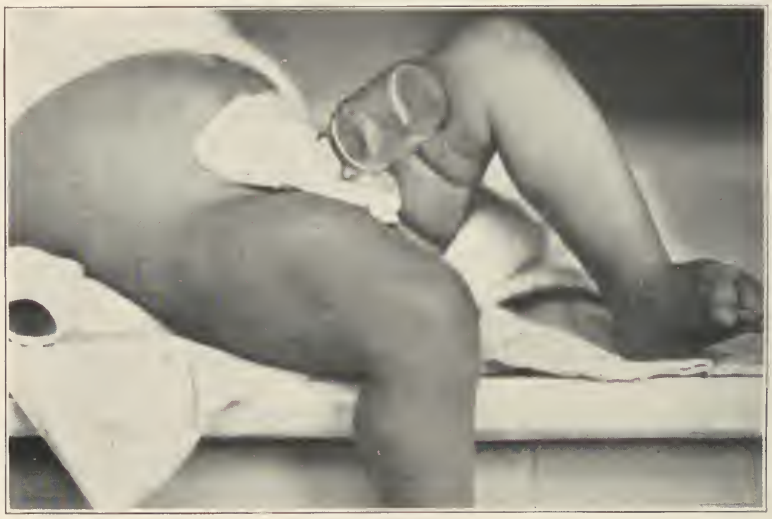

Fig. 40.—Method of collecting single specimen of urine.

From female infants, urine may be obtained by attaching a short wide-mouthed bottle over the vulva, fastening it in place by means of adhesive plaster pasted to the pubic area. Bird seed vessels and folded glass ink stands may also be used. The Schick model may also be used in female infants to advantage (Fig. 41).

Catheterization.—Catheterization should be avoided as much as possible, as it traumatizes the genitals and may cause infection of the genitourinary tract. When no specimen of urine can be obtained in any other way, or when a sterile specimen is desired for bacteriologic examination catheterization has to be employed.

Technic of Catheterization.—The infant is placed in the recumbent posture and the legs are spread apart. The genital organs are washed with cot-

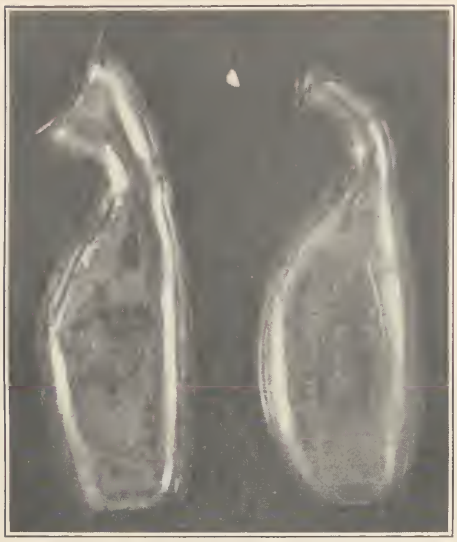

Fig. 41.—Urine collectors described by Schick.

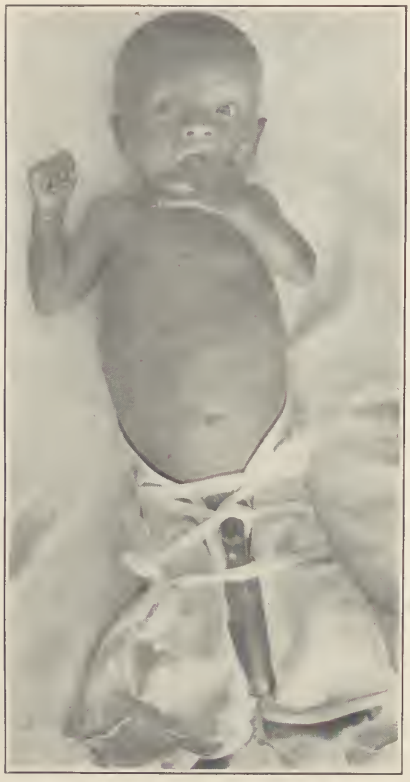

Fig. 42.—Urine collector held in place by gauze bandage.

ton saturated in 1 per cent lysol or in alcohol, or in 1 to 5,000 bichloride of mercury solution. A sterilized metal catheter, a rubber catheter (10 French) or a glass catheter, the last being the least desirable, is introduced for a dis-

tance of ½ to ⅔ of an inch in the female infant and 1 to 1½ inches in the male infant. An eustachian tube catheter (Fig. 43) is the ideal catheter for the female infant. A receptacle is held at the distal end of the catheter for the collection of the urine (Fig. 44).

Color.—In order to obtain any information from the color of the urine in infants and children, one has to keep in mind that the color of the urine changes with age, with the type of food, and with the amount of fluid consumed.

In the newly born, the urine is concentrated and often is of brick red color, supposedly due to uric acid infarcts present in the kidneys of the newly born. All through infancy, the urine is straw-colored. It becomes concentrated and assumes a light red color in diarrhea and in febrile conditions.

Fig. 43.—Eustachian tube which may be used as female urethral catheter.

Fig. 44.—Catheterization of a female infant.

In older children, the urine is also straw-colored, but may become more concentrated, after the ingestion of food. At times a brick red sediment, made up of uric acid, settles at the bottom of the container after the consumption of a large amount of meat. In all febrile conditions the urine is concentrated and may assume a dark red color.

In catarrhal jaundice, as well as in icterus neonatorum the urine is greenish red in color. In hemorrhagic nephritis the urine is dark red, and at times looks like pure blood. In tuberculosis of the kidney, in calculus of the kidney, ureters or bladder the color may also be bloody. In abscesses of the pelvis of the kidney and in pyelitis the urine may be very turbid.

Specific Gravity.—For clinical purposes, the ordinary urinometer furnishes valuable information. The specific gravity of the urine of the newborn is quite high, varying between 1.020 and 1.025. During infancy, the specific gravity varies between 1.010 and 1.018. It usually changes with the time of

the day and with the intake of food. A fixed specific gravity speaks for a pathologic condition. A persistently high specific gravity speaks for diabetes or acute nephritis. A persistently low specific gravity points to chronic nephritis. (See Mosenthal test.)

Reaction.—For clinical purposes, litmus paper may be used for the determination of the reaction of urine. Immediately after the urine has been voided, it is acid in reaction. On standing several hours it assumes a neutral or alkaline reaction. Urine is often alkaline one or two hours after ingestion of food. This is known as the "alkaline tide." Alkaline reaction in a fresh specimen, not following a meal, indicates stagnation of the urine in the bladder, as happens in paralysis of the bladder.

In the administration of alkalies for the treatment of pyelitis, the reaction of urine may serve as a guide as to how much alkalies to give. As soon as the reaction of the urine becomes alkaline, the alkalies should be discontinued. Table X from Palmer and Van Slyke may be utilized for the determination of the amount of alkali to be administered in order to turn the urine alkaline.

Table X

SODIUM BICARBONATE PER KILO BODY WEIGHT REQUIRED TO TURN URINE ALKALINE	MINIMUM PLASMA BICARBONATE CO_2 INDICATED	MAXIMUM DEGREE OF ACIDOSIS INDICATED
gm.	vol. per cent.	
0.0–0.5	55	None
0.5–0.8	55–40	Mild
9.8–1.1	40–30	Moderate to severe
Over 1.1	Below 30	Severe

Albumin.—The two most simple tests for albumin in urine are: The combined heat and acetic test and the nitric acid test. The combined heat and acetic acid test is done as follows:

The upper part of a tall column of urine in a test tube is heated. A few drops of 5 per cent acetic acid are added, and the urine is examined for a precipitate or turbidity by transmitted light against a dark background. A precipitate indicates the presence of albumin. Phosphates also produce a precipitate on heating, but the precipitate disappears on the addition of acetic acid, whereas an albumin coagulum will usually be intensified unless a considerable excess of acid is used.

The nitric acid test is carried out by letting a few drops of nitric acid run down from a pipette on the inner wall of a test tube containing 2 to 5 c.c. of urine. If albumin is present a white ring will appear at the contact of the nitric acid and the urine.

When several specimens of urine are to be examined, the nitric acid test can be simplified still further by having 5 to 6 c.c. of nitric acid in a test tube and by drawing up a small quantity of urine with a glass tube by capillary traction and introducing the lower end of the tube into the nitric acid. If albumin is present, a ring will form in the small tube on contact of the urine and acid.

Quantitative Albumin.—An Esbach tube used for this purpose is filled with urine to the mark "U" and the reagent is added to the mark "R." The reagent used is either that of Esbach, or that of Tsuchiya.

The Esbach reagent consists of a solution of 10 grams of picric acid, and 20 grams of citric acid in 1 liter of boiling water cooled off before using.

The Tsuchiya reagent consists of 1.5 gm. of phosphotungstic acid, 5 c.c. of concentrated hydrochloric acid and 95 per cent alcohol to make up to 100 c.c.

The Esbach tube is corked and inverted several times to insure thorough mixing, and allowed to stand in a vertical position for 24 hours. The height

Fig. 45-*A*.—Granular casts. (After Hawk.)

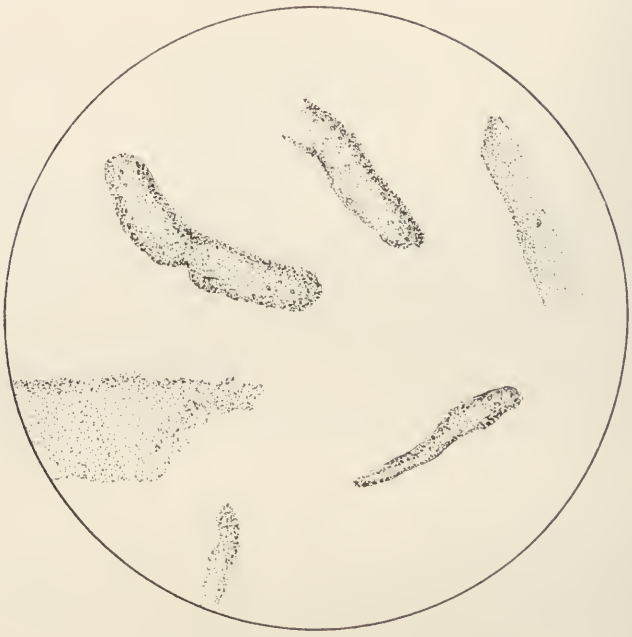

Fig. 45-*B*.—Granular casts. (After Peyer.)

of precipitate which settles to the bottom is read on the scale marked on the tube. The figure obtained gives the quantity of albumin in grams per liter of urine. From this the amount of albumin in the given 24 hour specimen is readily calculated. If the urine shows a heavy precipitate by the qualitative albumin test, it should be diluted 1 to 10 before the quantitative albumin reagent is added, and the final reading multiplied by 10.

Interpretation.—A negative albumin test is valuable in excluding nephritis. A positive albumin test does not necessarily mean the presence of a nephritis, as all infectious diseases may show a temporary albuminuria.

There is also a condition known as orthostatic albuminuria, where albumin is found in the urine of nonnephritic patients when the patient is up and around, and which disappears when the patient is in bed. It is wise, however, to keep all patients showing albuminuria under observation, so as not to overlook a nephritis. Quantitative albumin determination throws light on the amount of destruction going on in the kidneys, or the amount of protein of the blood permeated through the kidneys.

Qualitative Determination of Sugar.—Haines', Fehling's and Benedict's methods are commonly employed. Fehling's method has the disadvantage of consisting of two separate solutions. Haines' and Benedict's reagents are therefore most commonly used. Haines' solution is made by dissolving 8.314 gms. of copper sulphate in 400 c.c. of water, adding 40 c.c. of glycerin, and then 500 c.c. of 5 per cent potassium hydroxide. Two to 3 c.c. of Haines' solution is placed in a test tube and boiled gently. No precipitate should form. Several drops of urine are now added and the mixture brought to a

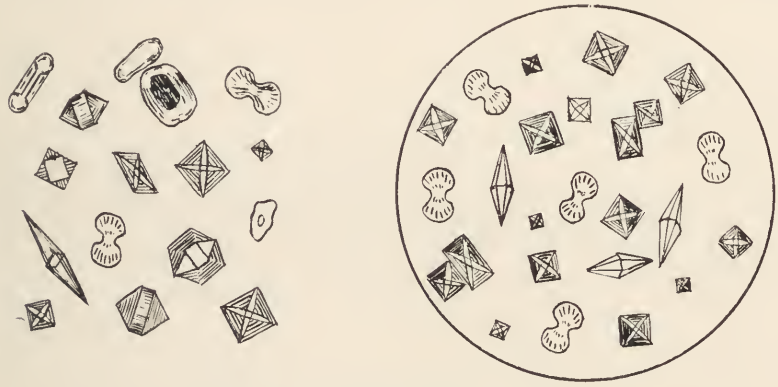

Fig. 45-*C*.—Calcium oxalate crystals.

boil. A yellow-red precipitate of copper oxide forms immediately or in a few minutes if sugar is present in the urine.

Fermentation Test.—In order to further ascertain that the reduction by Haine's or Benedict's test was due to sugar, a fermentation test is employed. A fermentation tube (Fig. 46) is filled up with urine and a small amount of yeast added to it. The tube is allowed to stand for twelve to twenty-four hours in an incubator or at room temperature. If the sugar is fermentable, gas will collect at the top of the tube, replacing the urine. The more fermentable sugar in the urine the greater the amount of gas. When no fermentation tube is handy, the test may be performed by placing 50 to 100 c.c. of urine in a small flask, adding ¼ of a cake of yeast to it, letting it stand for twenty-four hours, and then testing the urine again with Haine's or Fehling's solutions. If the reduction test is negative now, the sugar in the urine is fermentable and is most likely dextrose.

Osazone Test.—A more accurate test for the identification of the reducing substance is the osazone test, which is as follows:

To 5 c.c. of urine is added 1 c.c. of phenylhydrazine acetate solution

which consists of 2 parts of phenylhydrazine, 1 part of glacial acetic acid and 1 part of water. If sugar is present a crystalline sediment will form macroscopically. Microscopic examination will ascertain the type of crystal which in turn is characteristic for the various types of sugar.

Quantitative Determination of Sugar.—Haines', Fehling's and Benedict's methods may be used, the Benedict method being most frequently used.

The Benedict reagent is prepared as follows:

One hundred grams of anhydrous sodium carbonate, 200 gm. of sodium citrate, and 125 gm. of potassium sulphocyanate are dissolved over a flame in about 800 c.c. of water and filtered. In another vessel is dissolved 18 gm. of crystallized copper sulphate in 100 c.c. of water. The copper sulphate solution is now slowly added to the cooled-off filtrate with constant stirring.

Twenty-five c.c. of this reagent will reduce 0.050 gm. glucose and 0.053 gm. of levulose. It may be necessary to titrate the Benedict's solution to make certain that it will reduce 0.050 gm. of glucose. For the examination of the urine the following procedure is employed: Twenty-five c.c. of the

Fig. 46.—Fermentation tube.

Benedict reagent is measured into a porcelain evaporating dish, 5 or 10 gms. of solid anhydrous sodium carbonate is added. A small amount of talcum powder may be added to prevent bumping. This is now heated over a flame until the carbonate is dissolved. From a burette, urine, diluted 1 to 10, is run in until the blue color disappears, this being the end point. The reagent should be kept boiling during the titration.

To obtain the percentage of sugar in the urine, the following formula is used:

0.050 (amount of glucose reduced by quantity of reagent taken) is divided by X (the number of c.c. of diluted urine taken), times 1000 c.c. (100 x 10 which was the dilution of urine) or $\frac{0.050}{X \times 1000}$

Quantitative Sugar by Fermentation.—A very simple test, although less accurate than the titration method, is to utilize the specific gravity before and after fermentation of the sugar. The specific gravity of the twenty-four hour urine is determined. 100 c.c. of urine is put into a flask, and a quarter of a yeast cake added to it. The urine is allowed to stand twelve hours in an incubator and then tested for sugar reduction. If no sugar is

present the next morning the urine is made up again to 100 c.c. to make up for the loss by evaporation and the specific gravity is measured again. The difference in specific gravity between the original and fermented sample is multiplied by 0.23 and the resulting figure equals the percentage of sugar in the urine.

Interpretation.—The reduction tests for sugar are at times misleading. Often a reduction is obtained with Haines' or Benedict's solution that is grayish in color. This is due to the ingestion of salicylates or acetylsalicylic acid and must not be taken to indicate the presence of sugar in the urine. When in doubt, the fermentation test or the phenylhydrazine test should be employed. Ingestion of large quantities of sugar will give a temporary positive sugar test. When sugar is present in urine, the diagnosis of diabetes should not be made until several specimens have been examined and until the food factor (ingestion of large amounts of sugar) has been excluded, and until the sugar in the blood has been determined and found to be higher than normal. The latter will exclude renal diabetes.

Acetone.—To a few c.c. of urine are added a few drops of a freshly prepared solution of sodium nitroprusside and a few drops to ½ c.c. of glacial acetic acid. A small quantity of ammonium hydroxide is superimposed on it. A violet contact ring appears and becomes intensified in a minute or two if acetone is present in the urine.

Acetone in urine may be due to diabetes. In children, however, it is often present in urine in cases of prolonged starvation. Too much weight must therefore not be placed on the presence of acetone, except as an indication of starvation.

Diacetic Acid.—A few drops of 10 per cent ferric chloride are added to 5 c.c. of urine. If a precipitate (of phosphate) forms, ferric chloride is added until no more precipitate forms, and the solution is filtered. In the presence of diacetic acid a reddish brown (Burgundy-red) color appears. The color becomes weaker, or disappears on heating; if caused by drugs, like salicylic acid, aspirin, salol, diuretin and phenacetin, the color persists on boiling. A positive diacetic acid test points to acidosis and if there is clinical evidence of acidosis, alkalies should be administered.

Indican in the urine was at one time supposed to be an indication of the amount of putrefaction in the bowels. This, however, does not seem to be true.

Bile.—A few c.c. of urine is superimposed on 1 to 2 c.c. of concentrated nitric acid. A green ring, which may change to blue, violet, red or yellow, forms at the line of contact.

Microscopic Examination.—In acute nephritis casts and cells are present in the urine in such large amounts that they may be detected under the microscope in an uncentrifuged specimen. In less severe conditions the urine should be centrifuged, the supernatant fluid poured off, and the sediment examined on a clean slide under the microscope. The sediment should be spread in a thin layer, otherwise the examination is unsuccessful. A cover glass over the slide helps to even the layer of sediment.

Casts.—The presence of casts in urine indicates a destructive process going on in the kidneys. Granular, blood and hyaline casts are most important in the diagnosis of nephritis. Epithelial casts do not justify the diagnosis of nephritis. Care must be taken to differentiate between casts, crystals and debris. Most casts have rounded ends and parallel sides (Fig. 45).

Cells and Bacteria.—The presence of many red cells in the urine indicates hemorrhage, or at least marked irritation of the kidney. Such is the case in tuberculosis of the kidney and in hemorrhagic nephritis. An occasional white cell in the microscopic field is present even in normal urine. In pyelitis the white cells are present in large numbers, and are usually clumped. Epithelial cells are present in normal urine, particularly in female children.

In examining for tubercle bacilli the urine, which has preferably been standing in the refrigerator for 12 to 24 hours, is centrifuged for ½ to 1 hour and the sediment is stained by the Ziehl-Neelsen method. Enough alcohol should be used for decolorization in order to exclude smegma bacilli.

Crystals.—Uric acid crystals are of no significance. Their presence does not indicate an increased uric acid content of the urine.

Urates, calcium oxalate, and calcium carbonate are of no significance.

Triple phosphates, ammonium, magnesium and calcium phosphate are of significance. They occur in alkaline urine, and usually signify stagnation. The conditions are observed in paraplegia, chronic pyelitis, and chronic cystitis.

Blood.—In addition to the microscopic method, a chemical method may be used. The guaiac test is most often employed. The technic is as follows:

Freshly prepared tincture of guaiac (small amount of guaiac dissolved in a few c.c. of absolute alcohol) is added to 5 c.c. of the urine until the urine becomes turbid. Hydrogen peroxide is now added, drop by drop, until a blue color is produced, or until 2 c.c. has been added. If the urine contains either blood or pus, a deep blue color results.

Quantitative Tests.—The following are the most important quantitative tests:

Amount in 24 hours
Albumin and sugar when present (described above)
Total nitrogen
Urea nitrogen
Creatinine
Chlorides

Amount.—The amount of urine excreted in 24 hours is by itself a good kidney function test. An increased amount of urine is present in diabetes insipidus, and in chronic interstitial nephritis. The urine is decreased in amount in all febrile diseases, and in cardiorenal affections. As an arbitrary standard, 12 ounces should be considered the minimum amount of urine to be voided in 24 hours by a child between 6 to 12 years of age, and 16 ounces in 24 hours by a child above 12 years of age. The intake of fluid should be measured in conjunction with the urine output, as the latter is naturally influenced by the former. The bulk of the food ingested also influences the urine output. The bulkier the food, the greater the amount of urine.

In administering digitalis, the 24 hour urine output is an important guide in the therapy. If the urine is increased in amount after the administration of digitalis, the drug is performing its function. If the urine output is not increased by the medication, the digitalis is not producing its effect on the heart, or the decreased elimination of urine may be due to renal disturbances, instead of cardiac, for digitalis has no, or only slight, diuretic effect in renal conditions.

Total Nitrogen.—The total nitrogen in urine varies with the amount of protein ingested. On a mixed diet the total nitrogen output varies between 4 to 7 gm. in 24 hours, in normal children five to ten years of age. This amount is lessened in nephritis with retention, and in uremia.

Method of Determination.—The urine is diluted according to its specific gravity.

Specific Gravity	Dilution
1.010 or below	20:100 or 1:5
1.010 – 1.020	15:100 or about 1:6½
1.020 or above	10:100 or 1.10

One c.c. of the diluted urine is pipetted into a Pyrex nitrogen tube, and 2 c.c. of acid digestion mixture (see section on Blood, footnote No. 4) added. A glass bead is put into the mixture to prevent bumping. The mixture is now digested over the microburner, the same as in the determination of non-protein nitrogen constituents of the blood. After the addition of water the solution is transferred to a 200 c.c. volumetric flask. In another 200 c.c. flask a standard is made up containing 5 c.c. of the ammonium sulphate standard solution, 2 c.c. of acid digestion mixture, and about 125 c.c. of water. To each are added 30 c.c. of Nessler's solution (see section on Blood, footnote No. 6) and water to the mark. Readings are made against the standard and calculated according to the formula:

$$\frac{\text{Standard}}{\text{Reading}} \times \text{dilution} \times \frac{1}{1000} \times 24 \text{ hour volume} = \text{gm. of total nitrogen in 24 hours.}$$

Urea Nitrogen.—Urea nitrogen varies normally between 3 to 5.5 grams in 24 hours, or about 80 per cent of the total nitrogen. The amount is decreased in nephritis with retention and in uremia. It also varies in small limits with the amount of protein ingested.

Method of Determination.—One c.c. of the diluted urine (see total nitrogen in urine) is measured into a Pyrex tube. One drop of buffer mixture (see section on Blood, footnote No. 7), and one c.c. of urease solution (footnote No. 8) are added. The mixture is placed in water at 55° C. and allowed to stand for ten minutes. It is then transferred to a 200 c.c. volumetric flask. The standard is now prepared, consisting of ammonium sulphate standard solution, 1 c.c. of urease solution, and about 100 c.c. of water. Twenty c.c. of Nessler's solution are added to each, and water to the mark. Readings are made against the standard and the result calculated according to the formula:

$$\frac{\text{Standard}}{\text{Reading}} \times \text{dilution} \times \frac{1}{1000} \times 24 \text{ hour volume} = \text{gm. of urea nitrogen in 24 hours.}$$

A less accurate method of determining urea in the 24 hour quantity of urine, but one used extensively by clinicians is the hypobromide method, which consists of filling the Doremus' ureometer with sodium hypobromide and instilling 1 c.c. of urine into the ureometer with a curved pipette. The gas replacing the solution on the top is read off by the number on the ureometer and converted to percentage. Thus a reading of 0.01 equals 1 per cent urea, etc.

Creatinine.—The amount of creatinine in children's urine varies between 0.3 to 0.5 gm. in 24 hours.

Technic.—Into a 100 c.c. volumetric flask is measured 1-3 c.c. of urine. Into a similar flask is measured 1 c.c. of standard creatinine solution containing 1 mg. of creatinine (see creatinine in blood). To each is added 20 c.c. of saturated picric acid solution, and then, noting the time, 1.5 c.c. of 10 per cent NaOH. After standing for just ten minutes, the solutions are made up to the mark with water and read in the colorimeter, the standard being placed at 20.

$$\frac{\text{Standard}}{\text{Reading}} = \text{mg. of creatinine in volume of urine taken.}$$

Chlorides.—The amount of chlorides in normal urine varies between 2 to 4 gm. per 24 hours or between 0.7 to 1.0 per cent. Anything below 0.7 per cent speaks for the possibility of a threatening edema. The quantitative determination of chlorides therefore becomes a valuable kidney function test.

Two solutions are prepared for the test. Solution 1 consists of the following:

Anhydrous, crystallized silver nitrate, (C. P.)	29.055	gm.
25% Nitric acid in distilled water	900.	c.c.
Cold saturated solution of ammonioferric alum in distilled water	50.	c.c.
Distilled water, q. s.	1000	c.c.

Solution 2 consists of:

Ammonium sulphocyanate	7	gm.
Distilled water, q. s.	1000	c.c.

Solution 2 is intentionally made too strong, and must be standardized by adding distilled water in such an amount that exactly the last drop of 2 c.c. of this solution will bring about the end reaction when added to 1 c.c. of Solution 1. The end reaction consists of a reddish brown color, which does not disappear on moderate stirring. If the second last drop produces a discoloration which disappears rather slowly, and the last drop a deep brown color, the solution must be still further diluted, until the discoloration on the addition of the last drop is a light reddish-brown, which does not disappear on stirring fifteen to twenty seconds.

The test proper is made as follows: 0.5 c.c. of urine to be tested is placed in a porcelain dish, 1 c.c. of Solution 1 is then added and the mixture is stirred for about a minute with a glass rod. Solution 2 is now added drop

by drop by means of a 2 c.c. pipette graduated to at least .05 c.c. and the mixture is stirred until the brown color developing after each drop disappears. The amount of Solution 2 which has been used to bring about the end reaction is now read off, and the difference between this and 2 is equal

TABLE XI

CONSTITUENTS OF URINE IN NORMAL CHILDREN

Amount in 24 hours	360 to 480 c.c.
Specific gravity	1010 to 1018
Albumin	Negative
Sugar	"
Acetone	"
Casts	"
Cells	Few
Chlorides	0.7–1.0%
Chlorides (in 24 hours)	2 to 4 gm.
Total Nitrogen (in 24 hours)	4.0 to 7.2 gm.
Urea Nitrogen (in 24 hours)	3 to 5.5 gm. (80% of total nitrogen)
Creatinine (in 24 hours)	0.3 to 0.5 gm.
Ammonia Nitrogen	0.7 to 1.2%

to the number of grams of sodium chloride per 100 c.c. of the specimen tested. If, for example, it takes 1.26 c.c. of Solution 2 to bring about the end reaction, the amount of chloride in 100 c.c. of urine equals 2.-1.26 which equals 0.74 per cent of chlorides.

TABLE XII

CHEMICAL CONSTITUENTS OF BLOOD AND URINE IN SAME CHILD (NORMAL)

BLOOD

Mg. per 100 c.c.

Nonprotein Nitrogen	Urea Nitrogen	Ammonia Nitrogen	Uric Acid	Creatinine	Chlorides	Sugar
26.1	12.6	2-5	3.2	1.1	5.75	100

URINE

Gm. per 24 hours

Quantity	Total Nitrogen	Urea Nitrogen	Creatine	Creatinine	Chlorides
540	4.56	4.10	0.037	0.34	3.93

KIDNEY FUNCTION TESTS.—The two most commonly used tests are: The phenolsulphonephthalein and the Mosenthal.

PHENOLSULPHONEPHTHALEIN TEST.—A sterile solution of phenolsulphonephthalein, containing 6 mg. of the dye per 1 c.c. (may be obtained in ampoules) is injected subcutaneously. The patient is given large quantities of water preceding the test so as to cause diuresis. Ordinarily, the dye will appear in the urine in 10 minutes. Urine is collected during the first, second, and third hours in separate bottles.

Each specimen of the collected urine is made alkaline with 25 per cent sodium hydrate, enough sodium hydrate being added to produce a deep red color. The urine is now diluted with water to 1 liter and the readings are made by comparison with standard color tubes obtained on the market, or

by means of a colorimeter. The standard in this case is made up by making 1 c.c. of phenolphthalein solution alkaline by a few drops of sodium hydrate and diluting it to 1,000 c.c. Blood, if present, may be removed by using powdered lime or milk of lime, instead of sodium hydrate. This makes the solution alkaline and precipitates the blood pigments.

In normal children 70 to 80 per cent of the injected phenolsulphonephthalein is excreted in 2 hours; 40 to 50 per cent the first hour, and 20 to 30 per cent the second hour. In nephritis, the excretion of the dye is usually lowered according to the damage to the kidneys.

The phenolsulphonephthalein test, I believe, is only corroborative, but no diagnosis or prognosis should be based on it. I have seen patients in whom the phenolsulphonephthalein excretion was down to 5 per cent, who recovered, and others with 80 per cent phenolsulphonephthalein excretion, who died of insufficient kidney function.

Mosenthal Test.—The test lasts 24 hours. The bladder is emptied at 8 A. M. and the urine discarded. The patient is given his customary meal, and in addition, 1 quart of fluid. The same is done at noon, and at 5 P. M. No food is allowed at any other time. The amount of fluid may be increased or decreased according to the weather and to the age of the child.

The urine is collected in 2 hour specimens until 8 P.M., the patient voiding at the end of each 2 hour period in order to make each specimen complete. The night urine, from 8 P.M. to 8 A.M., is collected as one specimen.

The volume and specific gravity of each specimen is measured. Normally the night urine is small in amount and its specific gravity is high, being at least 8 points higher than the specific gravity of the day urine. When there is a disturbance in kidney function, the quantity of night urine increases above normal and shows a low specific gravity. The difference between the day and night urine is less than 8 points. In advanced functional disturbances of the kidneys, the specific gravity becomes fixed and low.

Stool

The first requirement in the interpretation of stool of infants is to examine it immediately after or only a short time after it has been dejected from the infant. Changes in color and consistency take place in stool on standing. Often a stool that is light yellow or deep yellow in color to start with, will take on a greenish or real green color on standing one or more hours. A stool that has been watery to start with often dries up on standing, leaving no residue or leaving only traces of stain on the diaper. One must also take into consideration the type of food ingested by the infant, especially the sugar, as the food influences the color, size, and consistency.

The next condition in examination of infant's stool is that no cathartic or laxative should have been given the baby on that day, for every cathartic changes the appearance of the stool. Castor oil, for instance, produces mucus in the stool even in a normal baby, and calomel produces a green color, whether or not there is intestinal disturbance to begin with. What is true

of physics is also true of other medications. Charcoal, for instance, shows black particles in the stool and argyrol colors the stool brown.

Examination.—The most important points in the examination of infant's stool are: number, size, consistency, color, odor, curds, reaction, fat, mucus, pus, blood, bacteria, and parasites. Size, color, and curds are determined by the naked eye. Reaction is determined by litmus paper, or by titration (easiest by litmus paper); fat is determined by sudan III or galactometer. Blood is determined macroscopically, microscopically, or by the guaiac test; pus is determined microscopically. Bacteria are determined both on slide and on culture media, special tubes and special media being used for culturing stools (see section on smears and cultures). Parasites are determined by the naked eye or by the microscope, parasitic ova are determined microscopically.

The number of bowel movements in healthy infants and children varies between 1 to 3. Some infants and children will, however, have only one bowel movement in 36 hours with untoward effects on their health. The food ingested also influences the number of stools. Boiled milk tends to constipate, vegetables tend to increase the number of bowel movements.

The size of the stool depends on the age of the child; the number of bowel movements, the character of the food, and the condition of the gastrointestinal tract. Infants' stools are necessarily smaller, as infants' food contains relatively less residue. When the diet is increased by cereals and vegetables, the stools increase in size because of the increased residue. In cases of starvation and partial intestinal obstruction, such as pyloric stenosis, chronic intussusception, and malformation of the rectum, the stools are small. In dilatation of the colon or Hirschsprung's disease, the stools are infrequent and very large, resembling an adult stool. In most cases of diarrhea the stools are small and numerous. In tenesmus due to any cause the stools are frequent and small.

The consistency of the stools varies with the diet and condition of the digestive tract—such as the thin fluid stool seen in diarrhea, often on relatively high carbohydrate feeding; the normal semiformed or soft stool seen in thriving infants and children; the firm formed and even hard stool in constipated children.

The color depends a great deal on the type of food ingested and on the time the stool has been standing before examination. Breast feeding often gives a deep yellow stool but does not always do so. Many breast fed children have a greenish looking stool. Cow's milk alone, or with cane sugar, usually gives a yellow colored stool. The addition of dextri-maltose to the milk changes the stool to a light brown, Mellin's Food changes it to a dark brown, and honey changes it to a light yellow.

One way of testing whether the stool has been green to begin with, or has become so on standing, is to examine the inner part of the stool. If the green color is due to oxidation, only the outside will be green, the rest being yellow. If the green is formed in the intestine, this color will be seen all through the stool. Green stool (the color being present in fresh stool) occurs in nearly all cases of diarrhea.

Normal infant's stool has no odor at all or it smells "sour." An offensive odor indicates disturbed digestion.

Large bean-shaped curds are often present in the stool when an infant is fed on raw milk. As soon as the milk is boiled or sodium citrate is added to the milk, the large curds disappear. Small curds varying in size from a pinhead to a linseed are present even in normal stools. When present in large numbers they may be indicative of disturbed fat digestion.

The reaction of a normal stool is neutral, faintly acid, or faintly alkaline. This may be ascertained by the use of litmus paper. If the stool is formed a suspension may be made with a small portion of stool and a few c.c. of distilled water. Diarrheal stools tend to be acid because of the presence of fermentation products. A high carbohydrate intake favors fermentation. When large amounts of fat are ingested, the resulting fatty acids tend toward acid stools. When high protein feedings are given there is putrefaction with resulting alkaline stools.

Fat in stools may be seen as neutral fat, fat soaps, and fatty acids. To examine for fat, a small amount of stool is smeared on a glass slide and a drop of sudan III stain added. This colors neutral fat bright red. Soaps do not stain. Fatty acids stain orange red. When a weak solution of carbol-fuchsin is used instead of sudan III the soaps stain a faint rose, the neutral fats do not stain, and the fatty acids are red. The crystals of fatty acids may be seen by adding a drop of acetic acid to the smear, and heating for a minute or so, and then allowing it to cool.

The presence of starch may be demonstrated by the addition of iodine which gives the starch granules the usual blue-black color.

Mucus may be seen as white, shiny, tenacious masses of varying amounts. Pus may be observed both macroscopically and microscopically.

Blood in the stool may impart a dark or tar color to the stool, as is the case when the hemorrhage is high up in the intestinal tract or of bright red or pink mixed with mucus. The latter is the case in infectious diarrhea. Fresh blood, from rectal fissures, polyps or ulcerations low in the intestine, appears bright red and is not thoroughly mixed with the stool. Sometimes blood is present in very small amounts and can be determined only microscopically or by chemical tests.

The Guaiac Test for Blood.—A water suspension of stool is prepared and one-third volume of glacial acetic acid is added and thoroughly mixed. If blood is present the coloring matter is thus converted to acid hematin. The mixture is now filtered and extracted with two or three volumes of ether. Fresh tincture of guaiac is prepared by dissolving a knife point of powdered guaiac in 5 c.c. of alcohol. About 2 c.c. of the ether extract is treated with 10 drops of the tincture of guaiac and 25 drops of hydrogen peroxide are added. After thorough mixing the presence of blood is evidenced by a blue color which fades on standing.

Worms.—Worms, especially round worms or ascaris lumbricoides, and tape worms or tenia, can be detected with the naked eye. Pin worms or oxyuris vermicularis can also be found if looked for carefully. The mother

may best do this when the child goes to bed. In looking for tape worm segments, the search can be facilitated by tying a large strip of gauze over the opening of the bed pan in which the stool is to be obtained. This is later placed in the sink under running cold water for an hour or two and the parasites are looked for in the residue. In looking for ova, a substantial amount of the stool is rubbed up thoroughly with several volumes of a saturated salt solution. The parasites rise to the surface, are scraped off with a spoon, and set aside for one hour. The surface of the fluid is now skimmed with a wire loop $\frac{1}{2}$ to $\frac{2}{3}$ inches in diameter, and several loops placed on the slide. This is examined under low power.

CHAPTER VIII

SKIN TESTS, SMEARS, AND CULTURES

Skin Tests

Of the numerous skin tests advocated the following have been found most useful:

Tuberculin tests, of which there are the von Pirquet, Mantoux, Subcutaneous, Moro and Calmette.

Schick diphtheria test.
Dick scarlet fever test.
Noguchi luetin test.
Protein sensitization tests.

Tuberculin Tests.—There is no agreement in the literature as to which of the tuberculin tests is preferable. Von Pirquet, Moro, Calmette, subcutaneous and intradermal tests have all been used. I have come to regard the von Pirquet and the intradermal as the most useful tuberculin tests.

The Von Pirquet Test.—An area of the forearm is cleansed with alcohol and followed by ether. Two drops of undiluted tuberculin (Koch's O.T.) are placed on the skin about 4 cm. apart. The skin is then scarified with a Pirquet bore or needle at a point between the drops for control and also over the spots containing the O.T. If the test is positive, redness and induration will appear over the areas containing the tuberculin, the control being unaffected (Fig. 47-*A*). The reaction usually appears in 24 hours and lasts three to four days.

The Intradermal Tuberculin Test.—Koch's O.T. is diluted 1 to 1000, 1 to 10,000 and 1 to 100,000, with normal salt solution. Two-tenths of a c.c. of the diluted tuberculin is injected intracutaneously. Infiltration and redness indicate a positive reaction (Fig. 47-*B*).

Interpretation.—A positive tuberculin test means that a tuberculous infection is present somewhere in the body. It does not, however, localize the infection, nor does it tell whether or not the infection is active at the time the test is made. The tuberculin test is of special importance in infants; as a positive test within the first two years of life is indicative of an active tuberculosis.

Schick Test.—Schick found that when $\frac{1}{50}$ of a minimal lethal dose of diphtheria toxin is injected intradermally, an area of redness and infiltration will appear at the spot of injection if the patient has not at least 0.03 unit of antitoxin per c.c. of blood. In other words, a positive reaction will take place if the patient is susceptible to diphtheria.

Technic.—Two-tenths c.c. of diluted diphtheria toxin (obtained from most health departments and some commercial houses) is injected into the

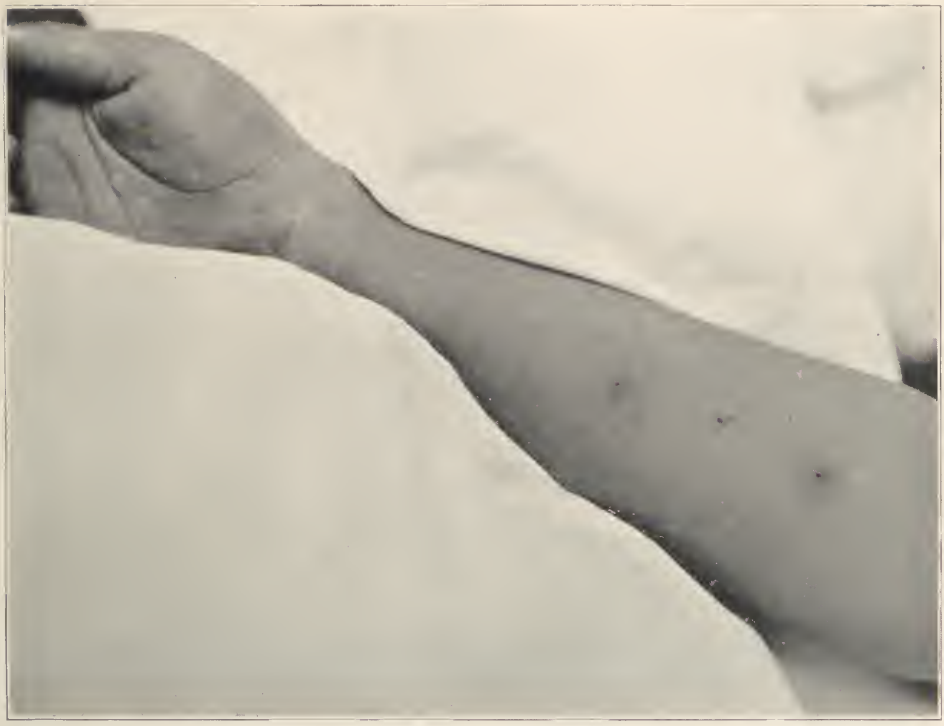

Fig. 47-*A*.—Positive von Pirquet reaction.

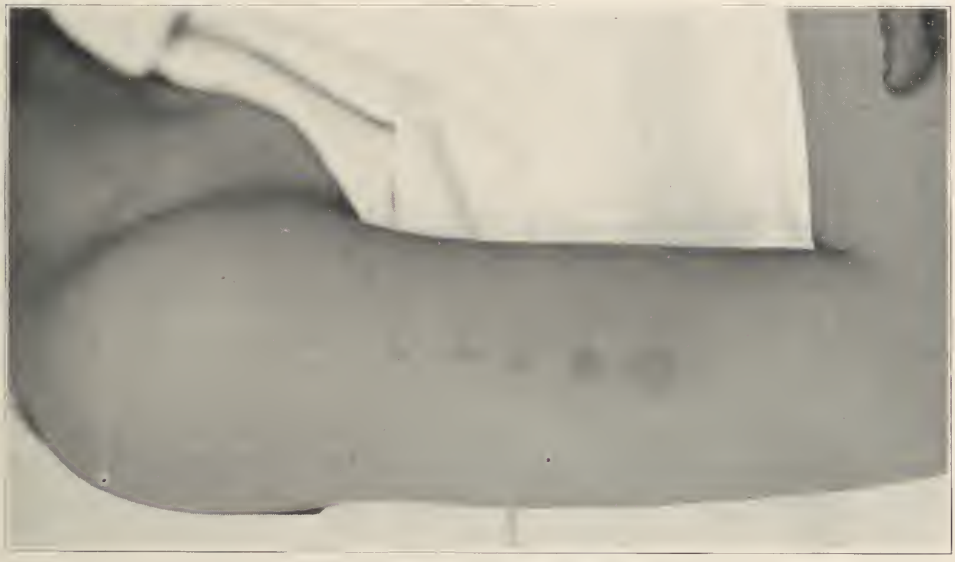

Fig. 47-*B*.—Positive intracutaneous tuberculin test.

forearm or interscapular region by means of a thin, short needle, care being taken that the solution is injected intradermally. The skin at the area of injection shows a whitened appearance with definite indentation if the fluid has been introduced intracutaneously instead of subcutaneously.

If the patient is susceptible to diphtheria, redness and infiltration will occur in 12 to 24 hours. Needle track redness should not be considered a positive reaction.

A positive Schick reaction does not necessarily mean that the disease in question is diphtheria; yet, if the patient showing the positive reaction has been exposed to diphtheria, he should receive the proper amount of antitoxin.

Toxin Antitoxin.—It is advised that children over five years of age who give a positive Schick reaction, should be immunized by toxin antitoxin (diphtheria toxin almost completely neutralized by antitoxin). Three injections of one c.c. each are given subcutaneously at 1 week intervals. Each c.c. should contain 3 lethal doses of diphtheria toxin. Recently only one tenth lethal dose has been advised for each injection. In children under five years of age, toxin antitoxin is advised even without a preliminary Schick test.

Immunity is supposed to develop from two to six months after the injection of toxin antitoxin and to last at least five years.

Dick Test.—The Dicks (G. F. and G. H.) described a skin test for the determination of a person's immunity to scarlet fever. The test consists of the intracutaneous injection of 0.1 c.c. of 1:1000 W filtrate of the streptococcus hemolyticus isolated by these authors. If the patient is immune to scarlet fever, no reaction takes place. If the patient is susceptible to scarlet fever, a bright red area with some swelling occurs at the point of injection within 12 to 24 hours.

Noguchi Luetin Test.—Noguchi described a cutaneous reaction for the diagnosis of syphilis. He injects an emulsion of dead spirochaetae called by him Luetin. If the patient is luetic, a papule or pustule forms at the site of injection in 24 to 48 hours. This test is only confirmatory and no diagnosis of lues should be made on this test alone.

Protein Sensitization.—It has been found that some children develop urticaria and even an asthmatic attack upon ingestion of certain protein. Other children have an asthmatic attack on coming in contact with certain pollen. A patient's susceptibility to protein may be determined by applying the suspected protein on the skin.

Technic.—The various proteins are obtained on the market in concentrated form. After the forearm has been washed with alcohol and dried with ether, one drop of a tenth normal solution of sodium or potassium hydroxide is applied to the skin by means of a sterile toothpick and the skin lightly scarified. A small amount of protein is now rubbed over the area containing the sodium or potassium hydroxide. If the patient is susceptible to the protein, the skin surrounding the tested area will show an urticaria and induration within ten to thirty minutes.

The following are the most important proteins from a pediatric standpoint.

Food Proteins.—

Carrot	Cow's milk	Spinach
Cheese	Oatmeal	Strawberry
Chicken	Orange	Tomato
Egg white	Pea	Veal
Egg yolk	Sweet potato	Wheat
Human milk	Rice	

Pollen Proteins.—

Goldenrod	Juniper	Rye
Ragweed	Oats	

Other Proteins.—

Horse Serum

Smears and Cultures

Among the most important smears used in pediatrics are the following:

1. From the mucous membrane of the mouth for Vincent's organism, and for Oidium albicans in thrush.
2. From the throat for Klebs-Loeffler bacilli, and for Vincent's organism.
3. From urine for typhoid, colon, and tubercle bacilli.
4. From the conjunctiva for gonococci, diphtheria, and for the Koch-Weeks bacilli.
5. From vulva and vagina for gonococci.
6. From stool, for examination of intestinal parasites and their ova.
7. From sputum for tubercle bacilli.
8. From skin lesions, such as in scabies, favus, and ringworm.
9. From various exudates.

The most common cultures taken from children are:

1. From throat and nose for the examination of Klebs-Loeffler bacilli, and for meningococci.
2. From blood for various organisms, especially pneumococci, streptococci, and typhoid bacilli.
3. From urine for typhoid and colon bacilli.
4. From stools for typhoid bacilli, dysentery bacilli, especially the Flexner type, for gas bacilli, and for streptococci.
5. From milk for diphtheria bacilli and streptococci, especially during epidemics of diphtheria, scarlet fever, and streptococcus sore throat.

Smears from the Mouth.—In all forms of eruption of the mouth a smear should be taken from the mucous membrane of the mouth, in search of the spirillum of Vincent and the oidium albicans of thrush. The detection of the spirillum is very important as it may cause fatal infection unless treated early with some arsenic preparations. In making a smear for the Vincent's organism the mucous membrane of the mouth is swabbed with a cotton applicator, and the material is put on a slide. The slide is dried in the flame and stained with carbolfuchsin, although methylene blue may answer the purpose, and examined under the microscope (Fig. 48-*A*).

For the detection of the organism in thrush the mucous membrane of the cheek is swabbed and the material applied on a slide, on which a few drops of 10 per cent NaOH or physiological salt solution has been placed.

Smears from the Throat and Nose.—The identification of Klebs-Loeffler bacilli in a direct smear from the throat, is difficult and unreliable, and should, therefore, be used only as corroborative evidence in making a positive diagnosis, the smear being followed by a culture. The same applies to smears from the nose.

When Vincent's angina is suspected, smears should be made for the presence of spirillum.

Eyes.—In all conjunctival exudates, especially in the newly born, smears should be made from the conjunctival exudate and examined for gonococci. Occasionally the exudate of the conjunctiva is dried up and a thin layer covers over the pus. In making conjunctival smears, therefore, the applicator should be rubbed firmly over the conjunctiva.

Occasionally one encounters diphtheria of the eye, especially in institutional children. A smear may show the Klebs-Loeffler organisms.

Fig. 48-*A*.—Throat smear from case of Vincent's angina.

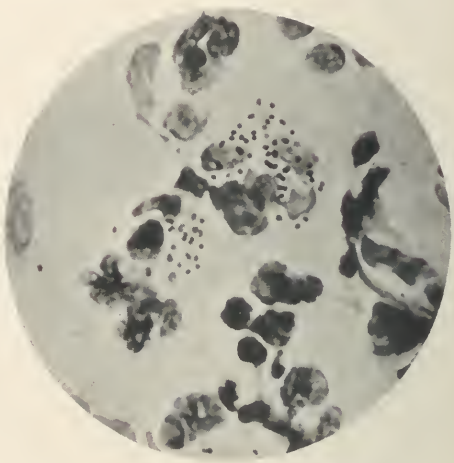

Fig. 48-*B*.—Positive vaginal smear.

Vaginal Smears.—Vaginal smears should be made from all vaginal discharges, and from all female children admitted to a children's hospital, in order to prevent epidemics of vaginitis.

The smear is made on a glass slide by means of a cotton applicator. The slide is dried in the flame and stained with methylene blue and if found suspicious, should be stained also with Gram stain. Gram negative intracellular organisms should be considered gonococci (Fig. 48-*B*).

Smears from Urine.—Whenever tuberculosis of the genitourinary tract is suspected, the urine, after standing several hours in a refrigerator, should be centrifuged for an hour or two and examined for tubercle bacilli.

When typhoid is suspected, the urine should be centrifuged and examined for typhoid bacilli.

Smears from Stool.—Smears from stools should be examined under the microscope for blood, for fat, and for parasitic ova. In examining for blood an unstained specimen may be used. In examining for fat, a drop of a

saturated solution of sudan III should be put on a slide. Fat appears as bright red droplets scattered through the field. In examining for ova, a saturated solution of sodium chloride should be used (method described in section on stool). In looking for Ameba dysenteriae the stool should be examined as soon after removal from the body as possible, and should be kept warm until put under the microscope, or a special apparatus should be used to keep the stage of the microscope warm.

Fig. 49.—Special specimen tube for stool cultures.

Smears from Sputum.—Children seldom raise sputum. When desired for examination, sputum may be obtained from children by irritating the pharynx with a tongue depressor. Children seldom suffer from the ulcerative type of tuberculosis of the lungs, so that only rarely does one find tubercle bacilli in children's sputum. Typing of pneumococci in sputum is being done by many workers.

Skin.—In looking for skin fungi, the scales, or hairs of the affected area are placed on a slide on which has been put a few drops of 10 per cent sodium hydroxide. The specimen is examined unstained for large spores, for scabies, and for ringworm.

Exudates.—Fluid obtained from the body should be examined on a slide for the number and type of cells, and for organisms. If the exudate is cloudy it is not necessary to centrifuge it. If thin, it should be centrifuged and the sediment used for smears.

In empyema or in abscess of the ears, a bacterial count may be used as an indication of the progress of the case. For clinical purposes the pus is put on a slide and a portion of the smear in which the cells are equally divided is selected and the bacteria in 10 successive microscopic fields, including those fields that contain no bacteria, are counted. The number of bacteria found in these 10 fields is then divided by 10 and the average number per field obtained.

Throat and Nose Cultures.—Any exudate in the throat and any discharge of the nose should be cultured for Klebs-Loeffler bacilli. This is especially true with reference to the nose. Many a case of nasal diphtheria is overlooked because the clinical symptoms are not so acute as in other forms of diphtheria. This subacute and dangerous form of diphtheria could be easily detected by a culture from the nasal discharge. It is a good rule to culture all nasal discharges, especially if they are mucopurulent or bloody. It should be pointed out that a patient whose culture contains organisms suspicious of diphtheria should receive antitoxin immediately, without waiting for a report of a second culture.

Technic.—The throat is swabbed by means of a sterile swab (supplied

by most Boards of Health), and the swab rubbed on Loeffler's blood serum. Care should be taken that the culture medium is not dry, for in that case no growth will take place. The box or test tube containing the medium is incubated in the incubator for 12 to 18 hours, or in the vest pocket for 18 to 24 hours, and the growth is put on a slide, stained with methylene blue, washed off with 0.3 per cent acetic acid and water and examined under the microscope with the oil immersion lens.

Occasionally the throat culture is positive, and yet the child does not suffer from an active diphtheria, and does not need any antitoxin. This is the case with diphtheria carriers. Still, it is best to follow the rule that each patient with a positive culture should receive antitoxin.

To discover meningococci carriers the postnasal space is swabbed by means of a bent wire applicator, blood agar or dextrose-agar being used as a culture medium.

A blood culture should be taken at the height of the disease for the determination of the offending organism (technic described in section on blood).

Cultures from Urine.—Cultures should be made only from specimen obtained by catheterization, otherwise the culture will be contaminated to begin with. Typhoid and colon bacilli constitute the most important organisms looked for in cultures from urine. Typhoid bacilli are examined for the purpose of diagnosis and colon bacilli for diagnosis and treatment; the latter when vaccine is contemplated for the treatment of pyelitis.

Stool.—In making cultures from stool it is best not to use the exposed surface of the stool but to remove the upper layer by a clean wood applicator. A small portion of the stool is transferred to the culture medium. If

Table XIII

Table Showing Staining Reaction of Various Common Bacteria to Gram Stain

GRAM POSITIVE	GRAM NEGATIVE
Cocci-Staphylococcus pyogenes aureus	Meningococcus
Staphylococcus pyogenes citreus	Gonococcus
Staphylococcus pyogenes albus	Micrococcus catarrhalis
Streptococcus hemolyticus	
Streptococcus mucosus	
Streptococcus viridans	
Micrococcus tetragenus	
Pneumococcus (Fraenkel)	
Bacilli	Pneumobacillus (Bacillus mucosus capsulatus of Friedlander)
Diphtheria (Klebs-Löffler)	Typhoid — Typhoid colon group
Pseudodiphtheria (Hoffmann)	Paratyphoid — Typhoid colon group
Leprae	Colon — Typhoid colon group
Tuberculosis	Dysentery — Typhoid colon group
Anthrax	Influenza
Tetanus	Spirillus fusiformis of Vincent
Aërogenes capsulatus (Welchii)	Malignant edema
Oidium albicans	Pyocyaneus
	Cholera
	Koch-Weeks (Pink-eye)
	Morax-Axenfeld
	Bordet-Gengou (Pertussis)

contamination by all other bacteria than the one looked for is to be completely avoided, a sterile, long glass rod or tube with the edges of the tube well rounded so as not to injure the rectum is introduced high up into the rectum, and a specimen obtained. This is transferred into the culture medium or into a sterile tube and closed with cotton (Fig. 49).

Routine Stains

A. Methylene Blue (Loeffler's Alkaline).
1. Fix—with heat.
2. Stain 30 seconds.
3. Wash quickly, dry on filter paper.

B. Gram Stain.
1. Fix—with heat.
2. Stain with carbol gentian violet—30 seconds.
3. Add Gram's iodine—1 minute.
4. Wash with absolute alcohol until smear is faint pink.
5. Wash with H_2O; let some water remain on slide, and
6. Add Safranin (5-6 drops for 15 seconds).
7. Dry with filter paper.

C. Stain for tubercle bacilli.
1. Dry smear in air or incubator and heat.
2. Stain with carbol fuchsin (Ziehl-Neelsen)—let it simmer on flamed tripod 3 minutes or more.
3. Add acid alcohol until smear is faint pink.
4. Wash with water—let water remain on slide.
5. Add methylene blue—4-5 drops for 30 seconds.
6. Dry with filter paper.

D. Capsule Stain (Welch).
1. Dry in air.
2. Fix and add glacial acetic-acid. Let stand 10 seconds.
3. Dry with filter paper.
4. Add carbol gentian violet—leave it on for 30 seconds.
5. Wash with 2 per cent solution of NaCl.
6. Dry with filter paper.

E. Wright Stain.
1. Stain 3 to 5 minutes, according to strength of stain. Count the drops.
2. Add an equal number of drops of distilled H_2O until metallic film appears. Let stand 2 minutes.
3. Wash with tap water.
4. Dry with filter paper.

CHAPTER IX

ROENTGENOGRAPHY AND FLUOROSCOPY IN CHILDREN

The roentgen ray is an important aid in both the diagnosis and treatment of many diseases of infants and children. It is, however, necessary to know what to ask for from the roentgenologist, and to be able to interpret the plate after it is developed, and above all to correlate the roentgenological

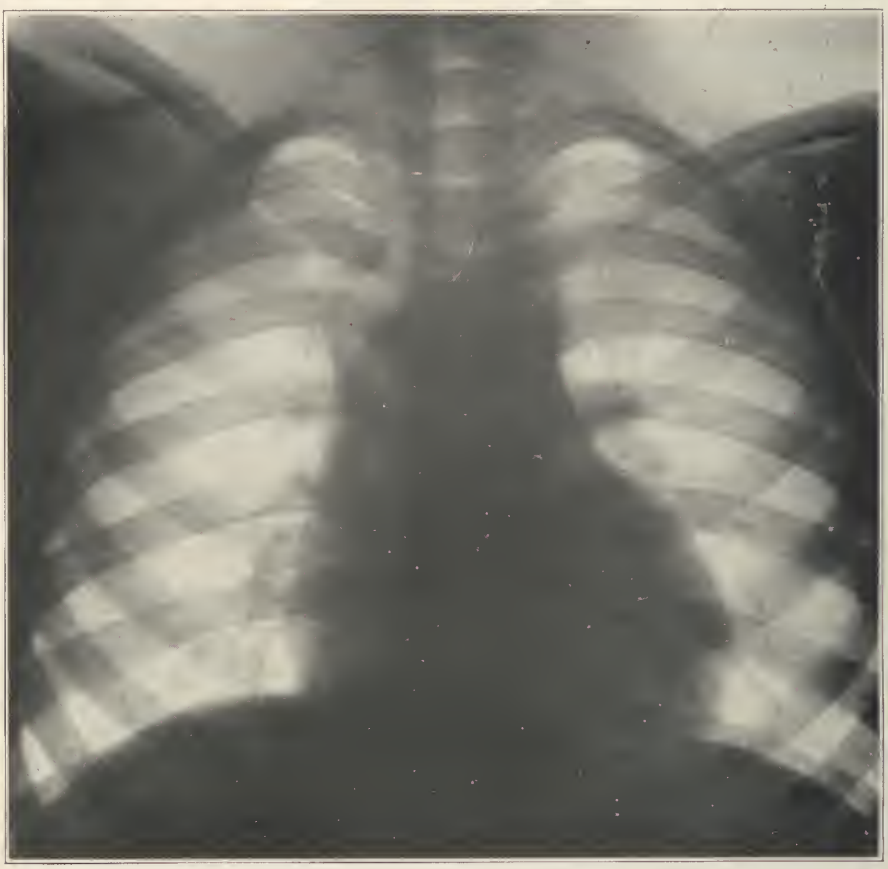

Fig. 50.—Chest of a child in good health showing some bronchial markings.

and the clinical pictures. The problem of keeping the child quiet during examination can, in part, be overcome by rapid work.

THE NORMAL CHEST

The roentgenogram of a normal chest is subject to wide variations, especially with reference to the bronchial marking, hilus shadow and nodes of calcifications. Indeed it is likely that a real normal chest seldom, if ever, comes under observation, as any chest needing x-ray examination usually has

some pathology in it to begin with. Furthermore, very few chests are clear of some infection or other. The term "normal" as generally used must therefore be considered as relative, rather than absolute.

A normal chest shows the outline of the heart, the lungs, the clavicle, the ribs, the diaphragm, and the scapula. An absolutely normal chest shows no areas of densities in the lungs. Some plates, however, show pronounced bronchial markings which fade before the outer third of the chest is reached. These children have usually gone through some previous lung infections which left some bronchial markings (Fig. 50). No diagnosis of active pathology should therefore be made on these markings.

Fig. 51.—Lobar pneumonia. Consolidation of right upper lobe.

A hilus shadow, especially if it is subdivided into small areas, indicates an infection which may be tuberculous in character, but does not necessarily speak for an active infection, nor does it necessarily speak for a tuberculous process, as many other infections, especially influenza, may leave a hilus density. The same is true with calcified nodes. They are suggestive of a latent tuberculosis, but no diagnosis of this disease must be made merely on their presence.

DISEASES OF THE LUNGS AND PLEURA

Lobar pneumonia is characterized by a shadow of increased density of the lobe involved (Fig. 51). The structural markings are not seen as a rule.

The borderline between the consolidated and the unaffected portions of the lung is usually very sharp.

Bronchopneumonia may show only very little change in the plate. Both bronchitis and bronchopneumonia may show small areas of increased density along the bronchial tree variable in size and shape with rather indefinite outlines. These may occur anywhere, but are frequently found at the bases (Fig. 52).

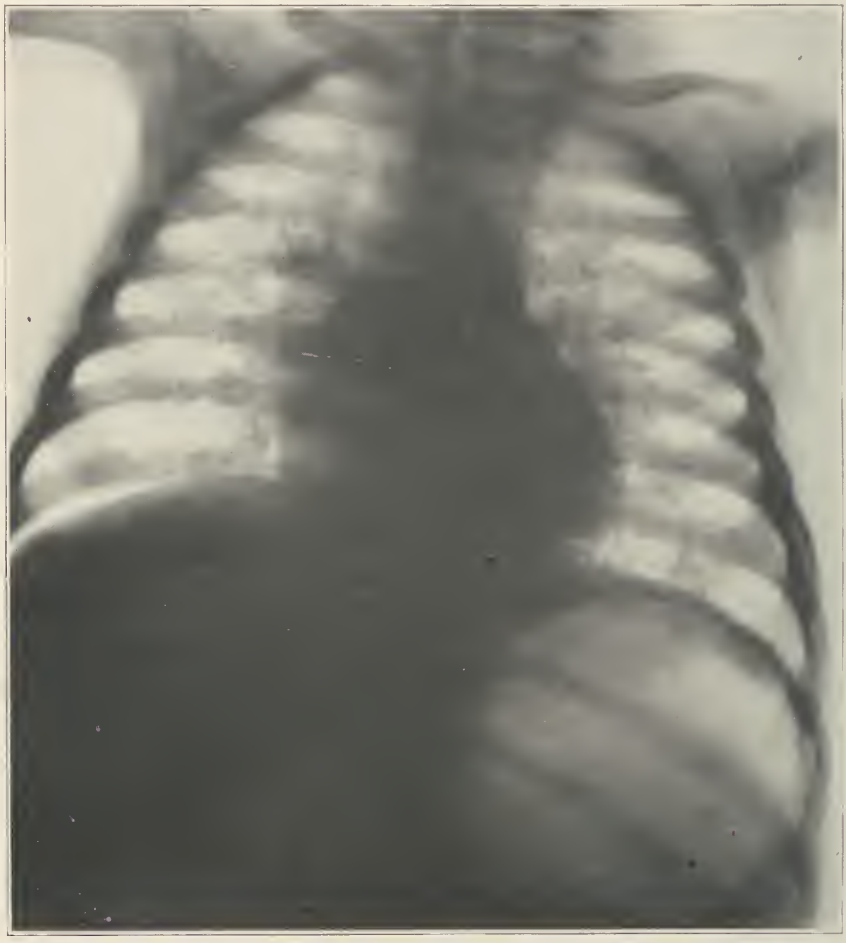

Fig. 52.—Bronchopneumonia.

Acute bronchitis may cause demonstrable roentgenographic changes. Chronic bronchitis may show increased markings followed well out into the periphery.

Tuberculous changes may be found anywhere in the lungs of children. The apical findings so frequently present in adults, however, are not common. Small shadows like a snowstorm scattered throughout the lungs are indicative of an acute miliary tuberculosis of the lungs (Fig. 53). The enlargement of the mediastinal shadow beyond the inner third of the chest speaks for enlarged tracheobronchial glands, which, in conjunction with

whispered bronchophony and positive tuberculin tests, speak for tuberculous glands, although no diagnosis of tuberculosis of tracheobronchial glands should be established on the hilus shadow.

Lung abscess is indicated by a clouding of the lung with a central necrotic area that is characterized by a dark area, of decreased resistance, surrounded by a dense peripheral zone.

Fluid in the chest cavity shows a shadow depending on the amount, on the location, and whether the fluid is free or encapsulated. Free fluid casts a shadow that may be seen to move upon change of position of the patient

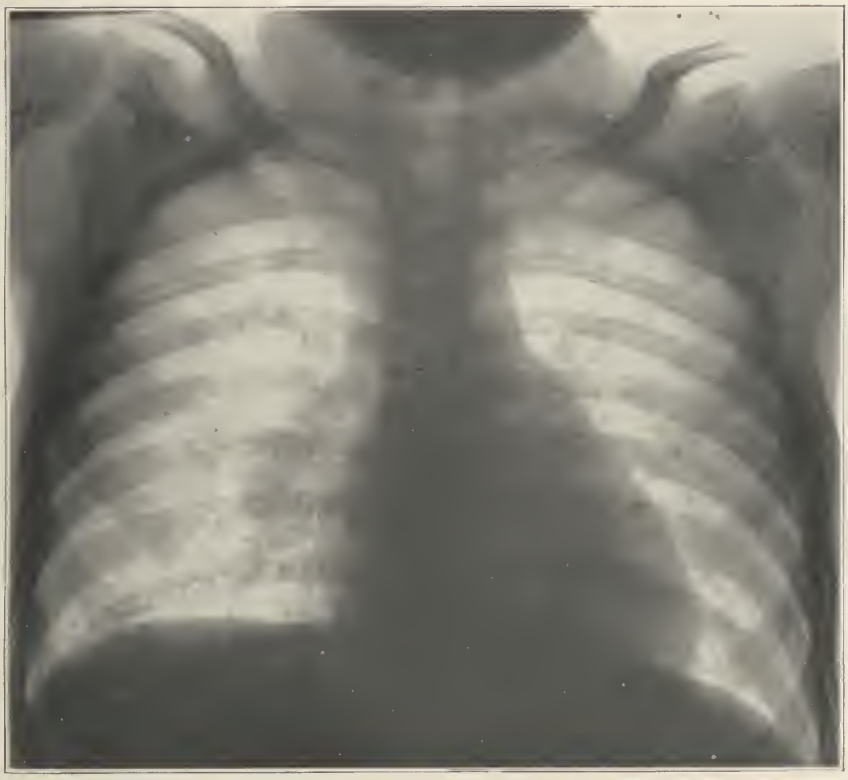

Fig. 53.—Miliary tuberculosis

when viewed under the fluoroscope. It tends to seek a level. It may cause a dense shadow along the costal margin, and may push the lung in for a considerable distance. The diaphragmatic angle is obliterated, and the heart and mediastinum may be pushed to the opposite side. The shadow cast by fluid is more or less dense (Figs. 54-55), the structural markings gradually disappearing as the fluid becomes more and more of a thickened purulent character.

Encapsulated fluid may be seen in any part of the chest where there are opposing pleural surfaces. The outline of the fluid is quite definite, and the shadow is dense and free of lung markings (Fig. 56). Thickened pleura may cast a shadow somewhat similar to a small amount of fluid.

Pneumothorax gives rather characteristic roentgenographic findings. The lung is compressed and pushed away from the thoracic wall. The air gives a transparent appearance to that portion of the chest, no structural markings are seen, and the edge of the collapsed lung is regular and sharply defined (Fig. 57).

Foreign bodies in the respiratory tract of children are of common occurrence. In relation to their examination by the roentgen ray, they may be

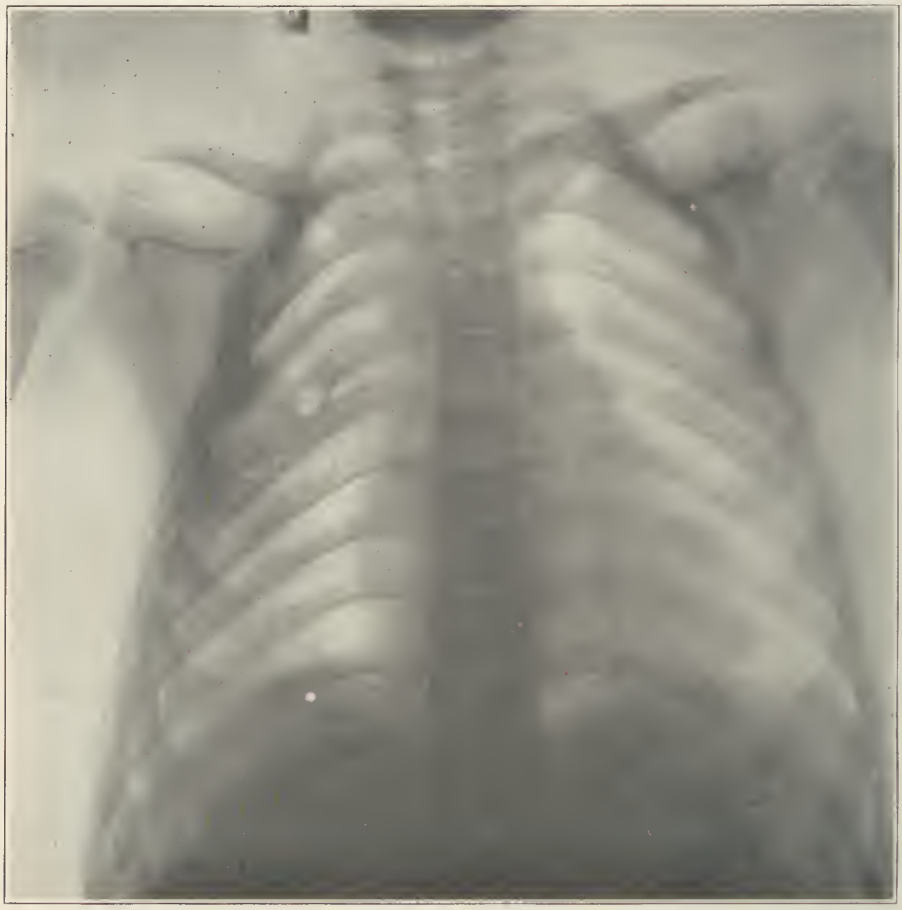

Fig. 54.—Postoperative pleural empyema on the right side, showing bridging of two ribs around drainage tube.

divided into two classes: opaque and nonopaque. The nonopaque bodies include peanuts, beans, seeds, and nut shells. The opaque are chiefly metallic.

The radiographic findings vary, depending on the position and nature of the resulting obstruction. A monolateral emphysema results when the foreign body has passed the bifurcation, and is of such nature as to cause obstruction to the expiratory current. This is evidenced by the increased transparency of the affected area and depression of the diaphragm with partial fixation on that side. The heart and mediastinum are displaced away from the affected side, and there is increased excursion of the diaphragm

on the opposite side. When the foreign body completely obstructs the bronchus to ingress and egress of air, the residual air is quickly absorbed and atelectasis results. There is marked density of the shadow of the area involved. The heart and mediastinum are displaced toward the affected side. The diaphragm is retracted upward. Metallic objects cast a shadow and their detection is much less difficult.

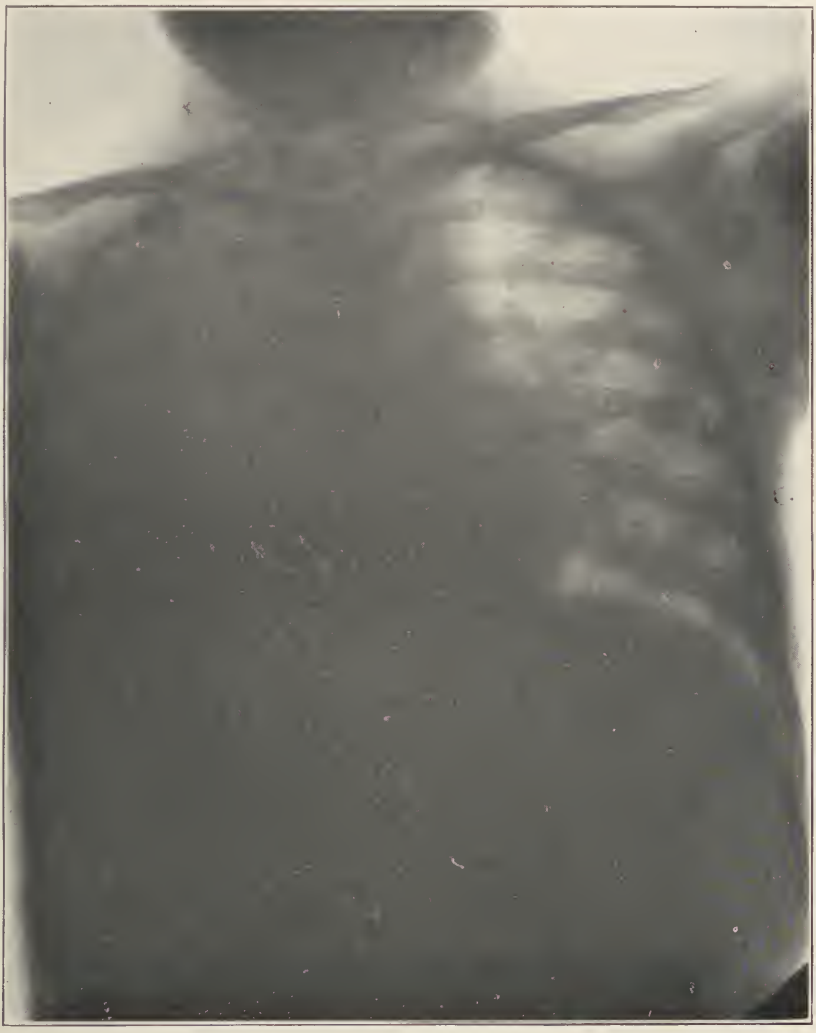

Fig. 55.—Empyema.

It is of the greatest importance to take roentgenograms at the end of full inspiration and at the end of expiration in order to show the above changes. The fluoroscope should always be used in the examination of these cases, and is of the greatest assistance in their removal.

HEART CONDITIONS

The heart shadow in children does not differ greatly from that of adults (Fig. 50). In infants the size of the heart in relation to the chest is increased.

Congenital heart disease does not always show demonstrable findings. Often enlargement of the pulmonary artery may be demonstrated. Alterations in the normal heart curve indicate a pathologic condition of the heart (Fig. 58).

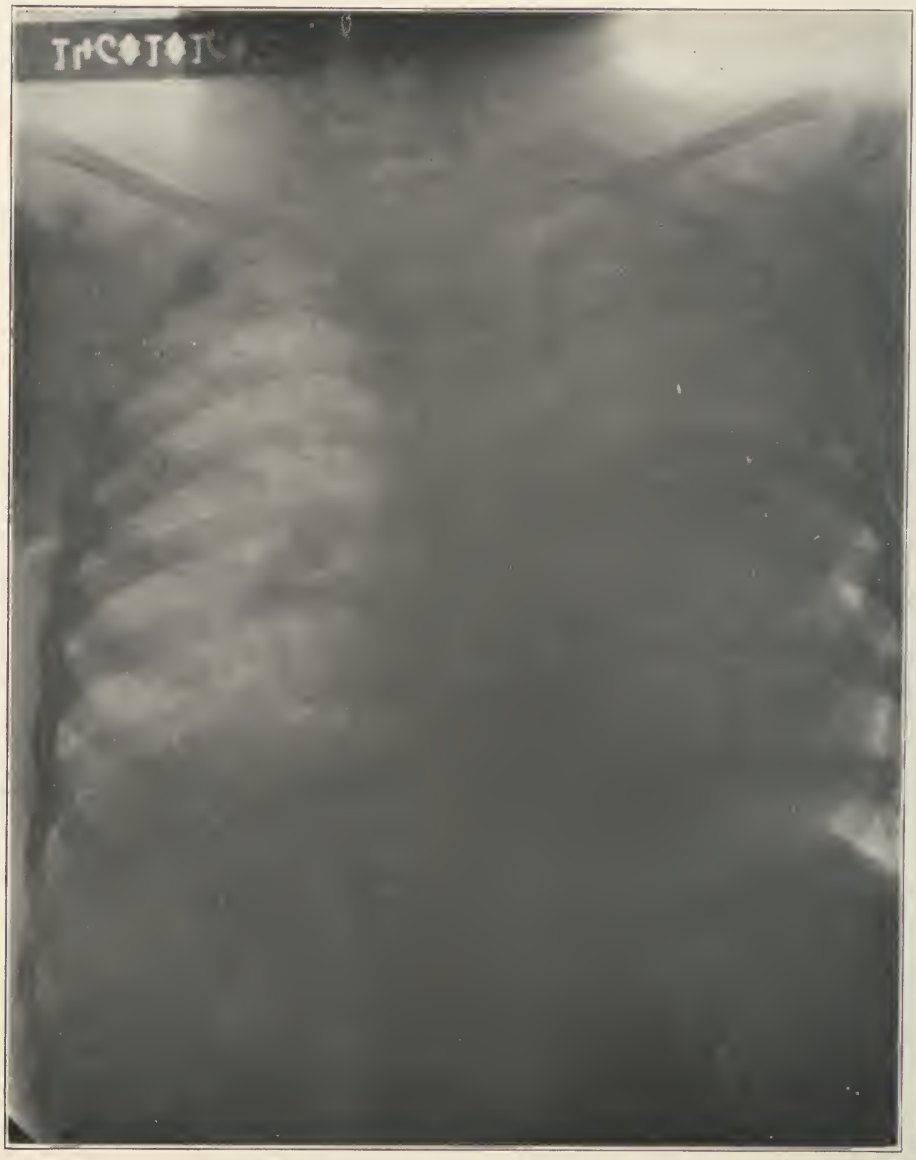

Fig. 56.—Encapsulated empyema (encysted).

Pericardial effusion casts an increased shadow, which tends to be pear-shaped (Fig. 59). Cardiac enlargement is often demonstrated by the roentgenogram. The fluoroscope is used to advantage in both of these conditions. For actual measurement of the cardiac outline, distance plates are taken in order that the shadow cast may be of actual size.

OTHER THORACIC CONDITIONS

Persistent thymus may be demonstrated by a homogeneous shadow extending downward from the clavicles on either side of the midsternum (Fig. 60). The width and extent of this shadow depend on the size and shape of the thymus.

The roentgen ray has also been found to be effective in the treatment of these cases. Overexposure, however, is to be avoided, because of the danger of skin burns, deleterious effect on the thyroid, and too rapid atrophy of the thymus.

Thoracic tumors are rare. Suffice it to mention the dense shadow which they cast, and the frequency of their origin from the mediastinum.

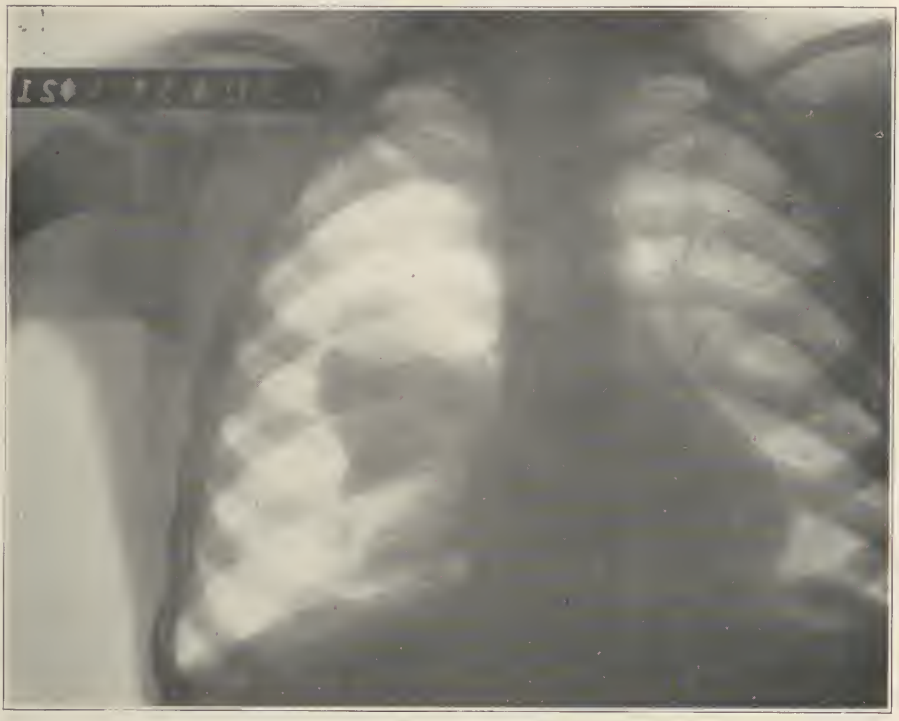

Fig. 57.—Right pneumonothorax with complete collapse of lung.

GASTROINTESTINAL CONDITIONS

In pyloric stenosis of infancy, and in other cases of persistent vomiting, the diagnosis may be expedited by following the course of an opaque meal, as shown by the fluoroscope and roentgenogram. The large dilated stomach, the thickened wall, the hyperperistaltic waves, and the reversed peristalsis may all be demonstrated. The percentage of the bismuth meal that passes the pylorus in a given time is indicative of the patency of the pylorus (Fig. 61). When one-half to two-thirds of the meal passes the pylorus in three hours, the immediate need of surgical interference is not indicated, and the condition, at most, is one of partial obstruction. If the bismuth is entirely re-

tained in the stomach after 4 hours there is complete obstruction of the pylorus and operation is indicated. Bismuth subcarbonate and barium are the salts most frequently used. They may be given in a small feeding in amounts of one-half to one ounce shortly before the examination is begun.

The information obtained by the observation of an opaque enema, by means of the roentgen ray, is of importance in cases of dilated colon and

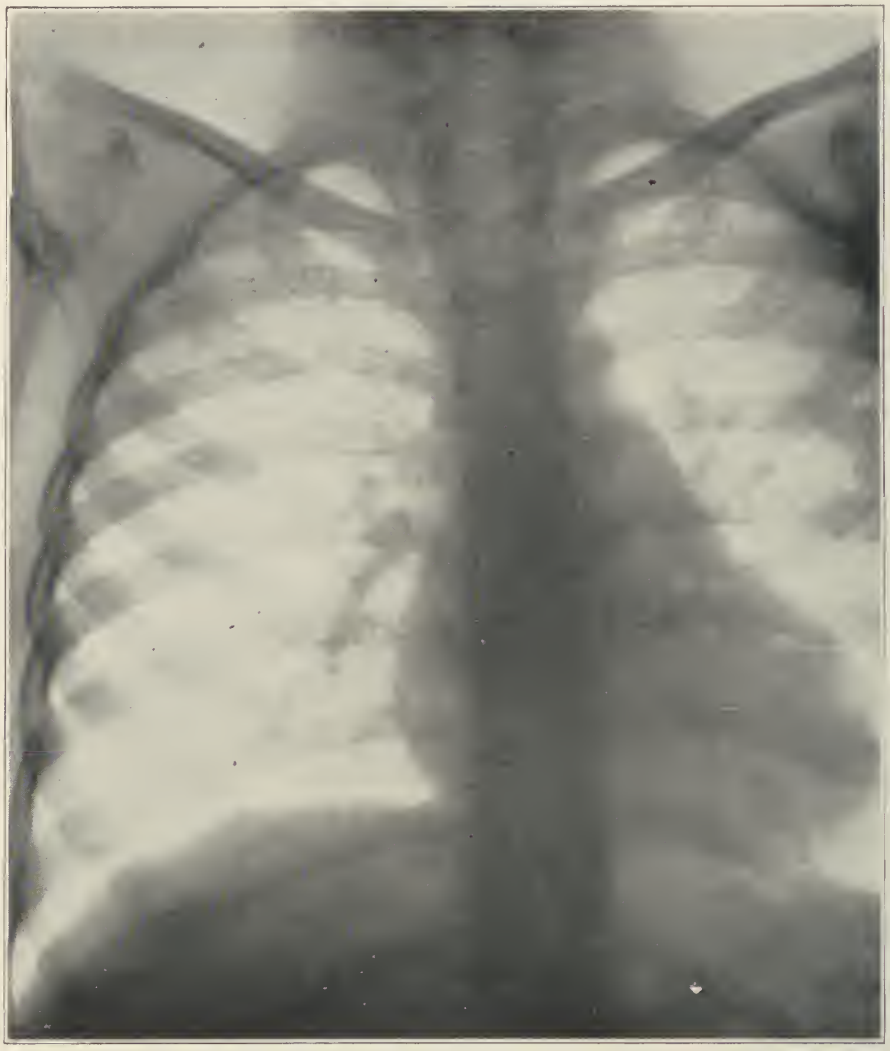

Fig. 58.—Pathological heart showing projection of left pulmonic curve.

Hirschsprung's disease. The increased diameter, looping, and any increase in length may be seen. Congenital malformation and polyps may also be demonstrated. Tumors of the intestinal tract, as well as other tumors in the abdomen, may be seen at times if they are of sufficient size and density.

Calculi in the kidneys, ureters, and bladder may be shown in the roentgenogram. The examination of the urinary tract by means of opaque in-

jections may be done, but it is not frequently carried out because of the added dangers and difficulty of the operation. Dilatation of the pelvis of the kidney, dilatation of the ureters, and diverticula of the bladder may be demonstrated by this procedure.

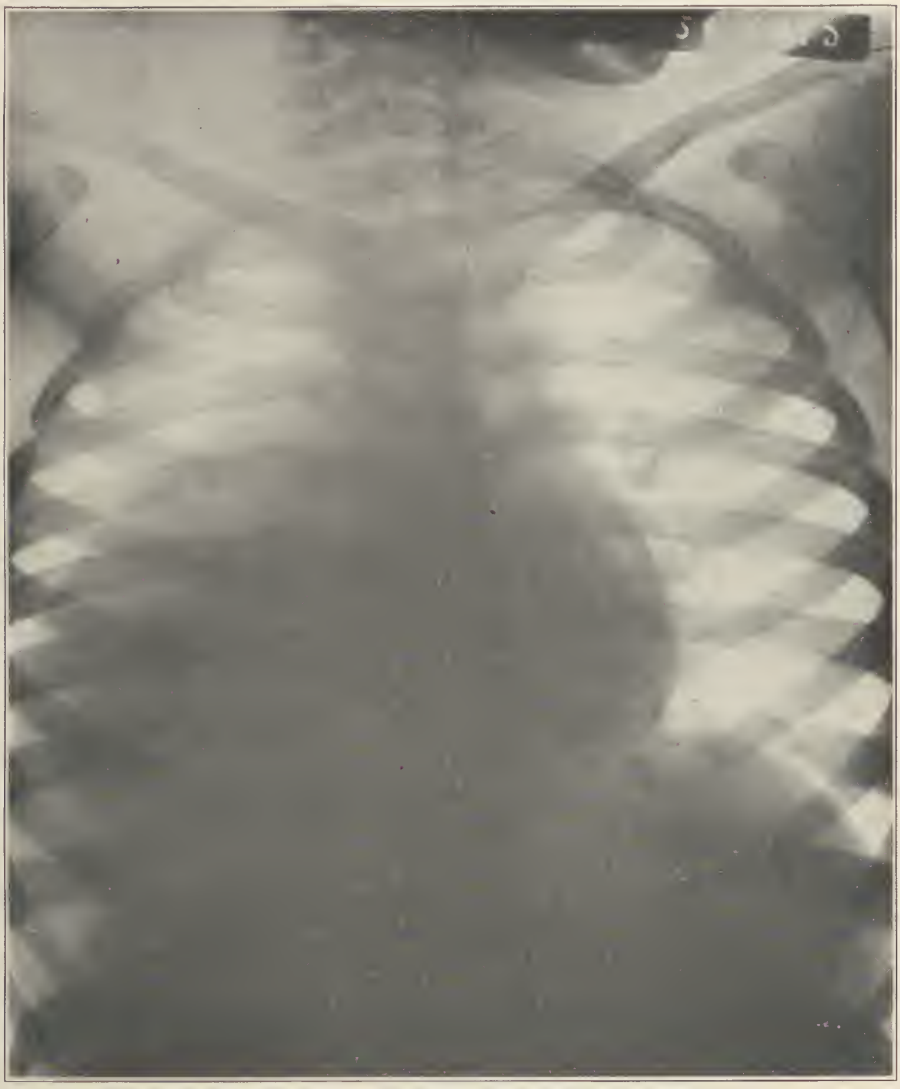

Fig. 59.—Pericarditis with effusion.

The roentgen ray examination of the mastoid, nasal sinuses, and teeth is of service in older children. The late development of the sinuses in children, makes their examination less frequently necessary in infants.

BONES AND JOINTS

Tuberculosis of the bone may be said to involve the epiphyses. Tuberculosis of the shaft is seen, but is rare. Tuberculous dactylitis is frequently seen

in tuberculous children and it may be impossible to differentiate the lesion from that of lues or osteomyelitis. Syphilis tends to involve more than one bone, and bone production is increased. Periostitis, and even tertiary lesions

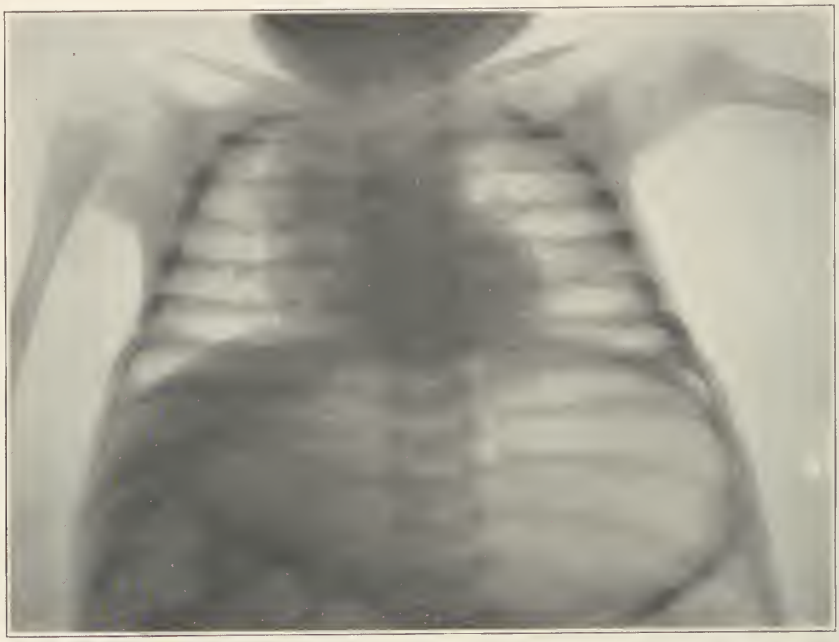

Fig. 60.—Persistent thymus. Broad superior mediastinum.

Fig. 61.—Pyloric stenosis showing gastric retention after four hours.

are often demonstrable in the roentgenogram. The serological tests and clinical course help to establish a definite diagnosis.

The most important differential points in the diagnosis of chronic bone and joint conditions in children may be summarized as follows:

Rickets.—There is multiple involvement. In the early stages, the diaphysis is frayed out and no longer clear cut. This becomes more marked, as the disease progresses, and there is a dense shadow cast by the margin which becomes wider, and has an inverted saucer-shaped appearance (Fig. 62). Atrophy is often present and fractures are not uncommon. In old cases,

Fig. 62.—Rickets, showing flaring out of ends of the long bones.

dense, transverse, linear shadows may be seen in the diaphysis, indicating a nutritional disturbance when the epiphysis was at that point.

Congenital Syphilis.—There is no spreading out of the epiphyseal line. There is no atrophy. Periostitis is usually present and is extensive. It is laminated and is usually found on the lower third of the fibula and radii.

Scurvy.—The epiphysis and epiphyseal line is undisturbed. There is a "white line" ½ millimeter behind the epiphyseal line, extending over the

entire bone outline (Fig. 63). Subperiosteal hemorrhage is nearly always present but it may not be seen in the skiagram. Epiphyseal separation may be present.

Fig. 63.—Scurvy showing the characteristic white line bordering the long bones (the line shows black in reproduction).

Tuberculosis.—The process is most often confined to one joint. Cartilaginous destruction is noted by the narrowing of the joint space. Irregular, worm-eaten appearance and general cloudiness is often observed.

PERTHES' DISEASE.—Perthes' disease is limited to the hip joint. There is no cloudiness, bone detail usually being clear cut. The epiphysis seems more flattened and denser than normal, and is not eroded or worm-eaten.

CHRONIC ARTHRITIS (Still's Disease).—The roentgenogram shows a thickening of the periarticular tissues, often distention of the joint. Osteoporosis may be noted.

Fig. 64.—Osteomyelitis of tibia with almost complete destruction.

OSTEOGENESIS IMPERFECTA.—There is decreased bone density; shortening of the long bones is present. Multiple fractures are nearly always present.

CHONDRODYSTROPHY.—There is marked shortening of all of the long bones. These give normal or increased shadows. The shortening is so marked as to cause little difficulty in the recognition of the condition.

Bone infections are frequent in children. Osteomyelitis is frequently acute. It is characterized by rapid bone destruction without bone regeneration due to the rapidity of the process.

The clinical findings may be such that a positive diagnosis can be made before any changes are seen in the roentgenogram. The earliest findings may be seen as areas of decreased density in the medullary cavity; later, when the infection has traveled into the cortex, areas of decreased density may be demonstrated. In less acute and in chronic cases bone destruction and regeneration may be seen (Fig. 64); still later, the sequestrum may be shown.

Bone Injuries.—Epiphyseal separation and injuries are frequent. The epiphyses at birth are for the most part cartilaginous, and are, therefore, not seen in the roentgenogram. Nutritional disturbances delay the appearance and development of the epiphyses. In roentgen ray examination it is of the greatest importance to know the time of the appearance of these ossification centers.

In children, when the force of an injury centers at the epiphysis, epiphyseal separation occurs more often than fracture. Fractures in children are often of the green-stick variety, due to the tendency of the bones to bend. The frequency of epiphyseal injury in children, and the difficulty in their recognition, both by clinical and roentgen ray examination, must be kept in mind in the diagnosis and treatment of injuries about the joints. Corresponding parts should always be examined, and the two compared, in order to determine the extent of the injury. Antero-posterior and lateral skiagraphs should be taken. The parts to be examined should be in close proximity to the film, or plate, in order to be as little distorted as possible.

Of the congenital dislocations, the hip and shoulders predominate. Congenital dislocation of the hip is often unnoticed until the child begins to walk, and it may be some time before any notice is taken of the waddling gait. In the roentgenogram, the shape of the pelvis, and the position of the head and neck of the femur in comparison with the normal side may make the diagnosis clear. The acquired dislocations usually occur in later childhood, and the findings are similar to adult dislocations.

The roentgen ray is useful after reduction of fractures and dislocations has been made to determine the apposition and alignment of the parts.

Table XIV

Development and Union of Some of the More Frequent Epiphyses

LOCATION	APPEARANCE	UNION
Humerus, head	6-8 mo. } fuse at about 6 yr.	17-18 yr.
trochanters	3-4 yr. }	
capitellum	1 yr.	
Internal condyle	5 yr.	
trochlea	10-11 yr.	
External condyle	12-14 yr.	
Radius		
Lower epiphysis	2-3 yr.	17 yr.
Olecranon	8-9 yr.	17-18 yr.
Femur, head	2-3 yr.	17-18 yr.
Lower epiphysis	at birth	18-20 yr.
Tibia, lower epiphysis	2-3 yr.	17-18 yr.

CHAPTER X

EXAMINATION OF MILK; LAVAGE AND GAVAGE; BLOOD PRESSURE; ELECTRICAL REACTIONS; BASAL METABOLISM

Milk

Human milk seldom requires chemical or bacteriologic examination. It may be taken for granted that a healthy mother has healthy milk. It has been found that with the exception of tuberculosis and syphilis the diseases of the mother do not affect the baby. There are some diseases of the mother besides tuberculosis and syphilis that contraindicate nursing, such, for instance, as carcinoma, diabetes, endocarditis, but this is not because of the disease being transmitted to the child, but because nursing would exhaust the mother. The composition of human milk does vary in different individuals and in various stages of lactation. The difference, however, is, as a rule, not sufficiently great to make examination worth while for clinical purposes. In cases of exudative diathesis, it may occasionally be wise to examine the fat content. In such cases, however, a large sample should be taken before and after nursing.

The quantity of mother's milk at a given feeding may be determined by weighing the child before and after nursing and also by watching the child's weight curve for a period of days or weeks.

Cow's milk should be examined bacteriologically and chemically. The bacterial count in any milk given to babies should not exceed 50,000 per cubic millimeter. In time of epidemics of diphtheria, scarlet fever, streptococcus sore throat, typhoid fever, or dysentery, the milk should be cultured for the respective bacteria. Instruction for collection of samples may be obtained from various boards of health. Milk may also have to be examined for tubercle bacilli and goat's milk for malta-fever organisms.

The fat in cow's milk should range between 3 and 4 per cent, unless the infant's condition requires a very low fat. The Babcock method is used extensively for this purpose. The sugar should vary between 3 and 4 per cent.

Milk given to babies should be obtained from healthy cows. The tuberculin test should be performed on all cows supplying milk for babies. The milkers should also be free from disease and should exercise the utmost cleanliness. For this reason certified milk, namely milk supervised by a special medical committee, which sees that the milk is obtained from healthy cows by healthy attendants and delivered in sealed bottles the day of milking, is preferable. Next to certified milk boiled milk is most useful, as boiling destroys the bacteria. Some pediatricians oppose the boiling of milk, because it destroys the vitamines. The latter, however, can be supplied by the addition of fruit juices, notably orange juice, tomato juice, and lemon juice. Pasteurized milk is used extensively all over the United States.

Bacterial Count.—Ninety-nine c.c. of sterile distilled water is placed in an Erlenmeyer flask. One c.c. of the diluted milk is now transferred to a sterile petri dish to which is added liquefied agar and litmus-lactose agar. The number of colonies are counted by a special colony counter after an incubation of forty-eight hours. The number of colonies counted is multiplied by the dilution.

A simpler but less accurate method is to count the number of clumps of bacteria and the number of cells by direct microscopic examination of the milk.

Fat Determination by the Babcock Method.—Special graduated testing bottles are used. Seventeen and five-tenths c.c. of milk or cream is put into one of these bottles. To this is added 17.5 c.c. of sulphuric acid, pouring it slowly down the side of the tube. The bottle is rotated to mix the acid and milk. The acid dissolves all of the solids in the milk except the fat, which is left in suspension. The tube is now centrifuged for five minutes. Then boiling water is added to bring the column of fat within the graduated part of the neck, and it is centrifuged for one minute. The percentage of fat is read by the scale on the bottle.

Several cream gauges and lactometers have been described for the determination of fat in milk, but they are not so accurate as the Babcock apparatus.

Lavage and Gavage

Indications.—Lavage is indicated in cases of severe vomiting due to food disturbances, especially when the vomitus contains large quantities of mucus. It is also indicated in poisoning. It is employed occasionally in older infants and children who refuse food because of neurosis.

Gavage is indicated when the child refuses food; when he is too weak to take food; when there is a deformity of the mouth, such as in marked cleft palate; in cases of stricture of the esophagus; in profuse persistent vomiting; and in postdiphtheric paralysis.

Technic.—The child is wrapped in a sheet and held firmly on the nurse's lap, or laid down flat on the table. The tongue is depressed with a tongue depressor, if the child has teeth, or with the index finger of the left hand if the child has no teeth. The catheter, held between the thumb and index finger of the right hand, is now passed quickly into the esophagus; the index finger of the left hand in the pharynx being used as a guide for the catheter.

The catheter should be soft, 12 to 14 French for infants, and 18 to 20 French for older children, especially if gavage is to be given, and if thick food, such as cereal, is to be introduced into the stomach. An idea of the length of the catheter to be inserted may be obtained by measuring the distance between the tip of the child's nose and the ensiform cartilage.

A funnel is attached to the catheter by means of an extra piece of rubber tubing, and a short glass tube used as a window. The glass part of a medicine dropper may be conveniently used for the latter purpose.

For lavage, a 2 per cent sodium bicarbonate solution, 1 to 2 per cent boric acid solution, or plain warm water is used. The solution is poured

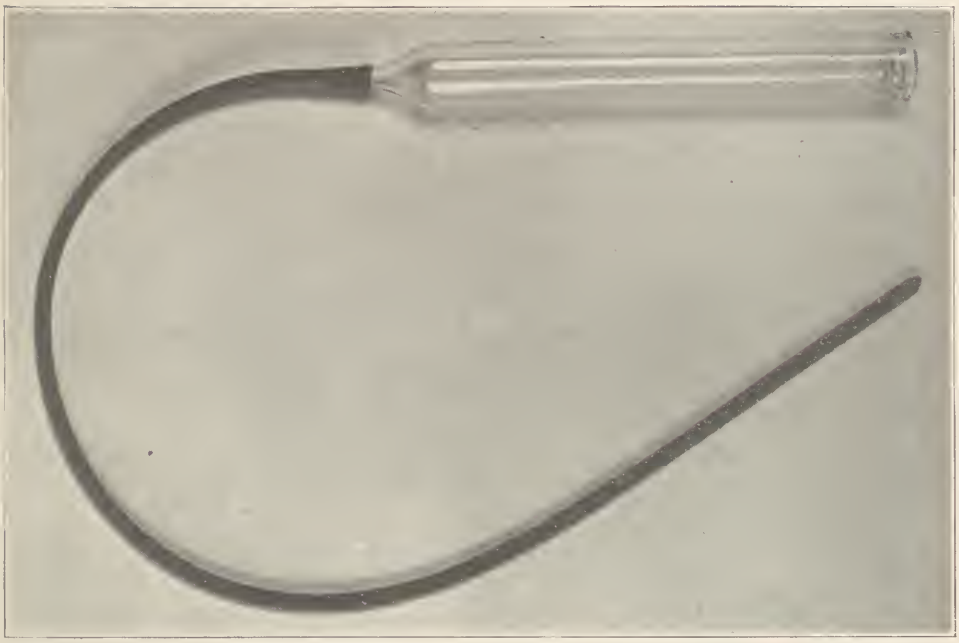

Fig. 65.—Barrel of glass syringe and catheter used for gavage.

Fig. 66.—Gavage.

into the funnel and allowed to run back by lowering the funnel. The procedure is repeated several times until no more food or mucus comes back with the solution.

For gavage the food is introduced into the funnel and allowed to run into the stomach gradually. The barrel of a ten c.c. glass syringe attached directly to a catheter may be used for gavage. (Figs. 65 and 66.)

A rubber apron for the physician and nurse, and a large basin as a receptacle for the stomach contents will facilitate lavage.

Nasal Feeding.—Nasal feeding may have to be resorted to in cases of paralysis of the pharynx, especially in acute anterior poliomyelitis and post-diphtheritic paralysis. It is also useful in cases of coma and in some neurotic children who refuse food and who cannot be forced to open their mouths without a struggle.

The technic of nasal feeding is the same as in the ordinary gavage, except that the catheter is introduced through the esophagus by way of the nostril, instead of by way of the pharynx.

Examination of the Gastric Contents

Our knowledge of the gastric juice in infants and children is still meager. It is known, however, that some infants with gastrointestinal disturbance have a lowered gastric acidity. This fact can be utilized in diagnosis as well as in treatment.

The gastric contents obtained either by vomiting or by lavage should be observed for quantity, for the color, for the type of curds, for mucus, for fibrin, and for blood. The acidity of the gastric content in older children may be examined the same as in adults, for total acidity, free hydrochloric acid and combined hydrochloric acid. In infants Marriott and his coworkers used thymol blue, methyl red and brom cresol purple as indicators. They found the acidity to vary between pH 3 and 4 with an average of 3.75.

Thoracentesis

Pleural Puncture.—Infants and children develop fluid in the pleural cavity quite frequently after pneumonia. The pleural fluid is usually purulent and is caused by pneumococcus or streptococcus and less frequently by the influenza bacillus and more rarely by the tubercle bacillus. Because of the frequency of empyema in children and because of the serious symptoms produced when a large quantity of fluid accumulates in the chest, thoracentesis should be done on mere suspicion of fluid in the chest. The procedure is harmless and of great value.

The following instruments are necessary for thoracentesis:

1. Needle 16 to 18 gauge.
2. Syringe.
3. Sterile tubes for collection of material for culture.
4. Slide for smear.

Technic.—The child is held firmly either in the recumbent or in the sitting posture. The dullest spot on the posterior chest is selected. As a

rule the spot immediately below the lower angle of the scapula will be found most suitable. The area is painted with iodine and washed with alcohol and a sterile towel is applied above and below the area of operation. Ethyl chloride may be used as a local anesthetic, but no general anesthetic must be used, the latter being dangerous. The needle, attached to the syringe, is now introduced into the chest ¼ to ½ inch deep and the plunger of the syringe withdrawn carefully (Fig. 67). If fluid appears the plunger is withdrawn still further. If no fluid appears the needle should be directed upward or downward, as the pus may be localized in a small area.

Fig. 67.—Pleural puncture.

After the pus is obtained the needle is withdrawn and the wound is closed with collodion. The pus is to be examined in direct smear and also cultured for the causative organisms.

Repeated punctures may be performed for therapeutic purposes.

Pericardial Puncture.—Clinical and pathologic investigations have disclosed the fact that infants and children suffer quite often from pericardial effusions. Endeavor should always be made to establish the diagnosis of pericarditis by percussion and auscultation. If this fails a pericardial puncture may be done. The puncture may also serve to withdraw the exudate for therapeutic purposes.

Technic.—The instruments necessary are the same as for pleural puncture. The child is placed in the recumbent posture. The cardiac area is washed with alcohol and iodine. The needle is introduced in the fourth or fifth interspace 2 to 2½ inches to left of the midsternum in the vicinity of the apex. If the needle moves in the chest like a pendulum, it is in the heart proper and should be withdrawn. If the needle does not move with the heart beats the plunger should be carefully withdrawn, and the barrel of the syringe watched for pus or serous fluid.

Blood Pressure in Children

Blood pressure determination may serve as useful a purpose in children as in adults. The apparatus to be used should have a small cuff to fit the child's arm. The systolic and diastolic readings should be taken, and the pulse pressure, which is the difference between the systolic and diastolic reading, should also be noted. When repeated, the measurements should preferably be made at the same time of the day, so as to exclude extraneous factors.

In infants under one year of age the blood pressure is about 80 mm. of mercury. It then rises with age (Table XV).

Table XV

Table of Blood Pressure Findings in Children of Various Ages

Up to 2 years	80 – 85
2 – 4 years	85 – 90
4 – 7 years	90 – 95
8 – 10 years	95 – 100
10 – 13 years	100 – 110
13 – 15 years	110 – 115
Adults	120 – 140

The normal blood pressure may approximately be figured by multiplying the age of the child by two and adding to it the number 80, the latter being the normal blood pressure reading in infants so that,

Blood pressure equals age x 2 plus 80.

For instance, the blood pressure in a child 5 years of age should be 5 x 2 plus 80 which equals 90. In a child of 10 it should be 10 x 2 plus 80 which equals 100.

The blood pressure is increased in the early stages of the acute infectious diseases, in acute nephritis, and in chronic interstitial nephritis. It is decreased in decompensation of the heart, in severe nutritional disturbances of infancy, in epidemic influenza (not in grippe) and in infectious diseases accompanied by insufficient heart function and a bad prognosis.

Electrical Reaction

Hyperexcitability of an infant toward a galvanic current is considered the most important sign of spasmophilia or tetany (Erb's sign).

In normal infants 6 to 9 milliamperes are required to obtain a cathodal opening contraction (COC), 5 to 6 milliamperes for an anodal opening contraction (AOC). In children over two years AOC may be obtained with less

than 5 milliamperes; 3 to 4 milliamperes for an anodal closing contraction (ACC), and 2 to 3 milliamperes for a cathodal closing contraction (CCC).

In spasmophilic infants, both AOC and COC may be obtained with less than 5 milliamperes, at times even with 1 milliampere. It can easily be seen that COC is the most important electrical reaction for the diagnosis of spasmophilia.

Method.—A galvanic current from a small dry cell battery may be used. A flat electrode is placed on the infant's chest or abdomen and a small round electrode is placed at the bend of the elbow (median nerve) or in the outer portion of the popliteal space (peroneal nerve) (Fig. 68).

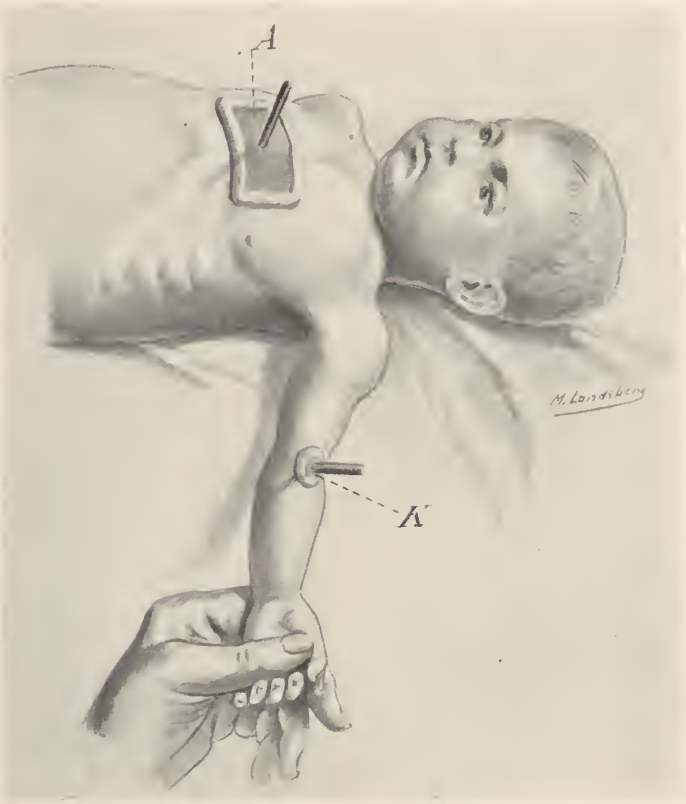

Fig. 68.—Method of testing the electrical hyperexcitability. *A*, Anode. *K*, Cathode.

Contractions of the fingers (in case of median nerve irritation) and of the toes (in case of peroneal nerve irritation) are looked for with cathodal opening. The pole is then reversed and anodal opening contractions are looked for. At first a very weak current is used, starting with 1 to 2 milliamperes. When no cathodal opening contraction is obtained, the current is increased till a contraction is obtained.

Basal Metabolism

The determination of basal metabolism is important in the diagnosis of hypothyroidism in which case the basal metabolism is decreased, and hyper-

thyroidism in which case the basal metabolism is increased. It is usually difficult to keep a child at rest during the examination. One must therefore allow for a certain percentage of error. However, if the final reading registers 15 per cent below or above, the evidence should be considered strongly corroborative.

Mentality Tests.—The Binet-Simon test has standardized the mentality of children, making it possible to classify a child in a particular group. The greatest fault of the test, however, lies in the fact that it was made on French children originally, and not enough differentiation for other nationalities was allowed. Yet, in spite of that, it is probably the best mentality test at present available.

CHAPTER XI

INTRODUCTION OF FLUID INTO THE CHILD'S BODY

The introduction of fluid into the body is at times a life-saving measure. Giving water by mouth is, of course, the best method of introducing fluid into the body. At times, however, this is impossible, either because the child is too weak to take it, or because he cannot retain it. It then becomes necessary to introduce fluid by other routes.

The most important indication for the introduction of fluid is dehydration from whatever cause. This is most frequent in hemorrhage due to trauma and in vomiting or diarrhea where so much fluid is lost that the blood becomes concentrated. The kind of fluid to be introduced and the method of introduction depends on the severity of the case and on the amount of fluid to be introduced. In the main, one of the three types of fluid is introduced. These are: saline, glucose and blood.

Saline.—Normal salt solution is used. One-fiftieth of the bodyweight is taken by some as the average amount to be introduced. In marked dehydration, more should be given. It should be introduced by one of the following routes:

1. Rectal.
2. Subcutaneous.
3. Intravenous, including longitudinal sinus.
4. Intraperitoneal.

The rectal route is used by surgeons in postoperative treatment of abdominal operations. It is usually introduced by the drip method. This method, however, is very slow and not all the fluid is retained. Another drawback is the irritation of the anus and rectum produced by the tube. The rectal route is therefore not to be recommended in dehydration, especially in diarrhea where the rectum is already irritated.

The subcutaneous route is very simple and is being used extensively in pediatrics. The fluid may be introduced either by means of a syringe, leaving the needle in place and refilling the syringe, or by gravity from a bottle with or without a syphon arrangement. The place of introduction is the axilla, chest or abdomen. When large quantities must be introduced the needle has to be withdrawn and reinserted in some other place.

The intravenous route is satisfactory if the vein can be entered. Often, however, it is difficult to enter the vein of a young child. The introduction of the saline into the vein should be by the gravity method, as by the syringe method air may be introduced into the circulation.

The longitudinal sinus route is useful for introduction of fluid, but care must be taken that no blood is lost in entering the sinus and that the fluid

is not injected outside the sinus, so as not to increase the intracranial pressure.

The intraperitoneal route is used extensively in pediatrics. A needle 16 or 18 gauge, 2 to 2½ inches in length is introduced either in the midline of the abdomen 1 to 1½ inches below the umbilicus, care being taken to avoid the bladder, or immediately outside the rectus muscle 1½ to 2 inches to one side of the midline. The needle is introduced downwards until no more resistance is encountered. It is then turned laterally. The latter procedure will prevent the needle from piercing the intestine, although the intestine is so elastic that there is seldom any danger of piercing it, even if the needle is directed downwards. Fluid is introduced by means of a syringe or by the gravity method.

Glucose.—If it is desired to introduce some nourishment into the body in addition to the supply of fluid, glucose should be used instead of saline. The purified glucose is preferable to the commercial, although the latter may also be used. It may be given in various concentrations. It is, however, best not to use a solution stronger than 3 per cent.

The objections to the rectal administration of saline are even more applicable to glucose as the latter produces a marked irritation of the rectum in a short period. It may be given subcutaneously but occasionally it produces an irritation and even sloughing of the skin. It is therefore best to give glucose intravenously or intraperitoneally. The method of administration is the same as for saline.

Blood Transfusion.—The indications are the same as for introduction of saline and glucose. Blood transfusion should in addition be considered in severe sepsis, jaundice, various anemias of childhood, hemophilia, and hemorrhage of the newborn. Blood may be introduced into the body by one of the following routes:

1. Intramuscularly.
2. Intraperitoneally.
3. Intravenously.

Implements Necessary.—The number of vessels and instruments necessary depends on the method to be used for the introduction of the blood into the child. If the blood is to be given intramuscularly or intraperitoneally, only 2 needles, 18 to 20 gauge, 2 Luer syringes and a tourniquet are necessary. If the blood is to be introduced into the median basilic vein or into the sinus, the following vessels and solutions are necessary:

(a) One venipuncture needle, for the removal of blood from the donor.

(b) One needle for the introduction of blood into the child. The size of the needle depends on the route to be used for the introduction of the blood. If it is to be introduced into a vein on the child's arm or leg, or into the external jugular vein, a regular venipuncture needle is to be used. If it is to be introduced into the longitudinal sinus, a short sinus needle is to be used.

(c) One Luer syringe of 50 c.c. capacity or two of 20 c.c. capacity, to be used for the removal of the blood.

(d) Two per cent sterile solution of sodium citrate. Ten c.c. of citrate to be used for each 100 c.c. of blood.

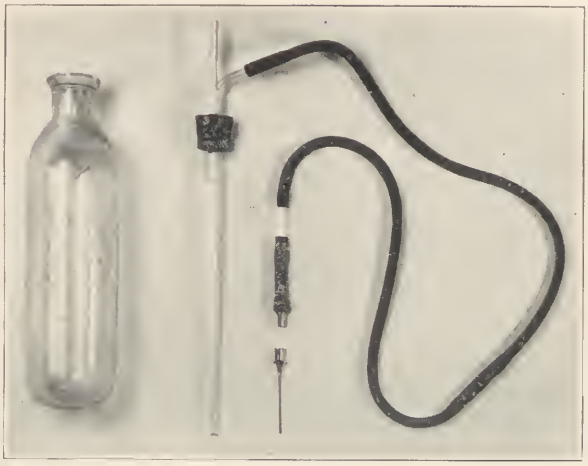

Fig. 69.—Bottle, rubber tubing, metal tip and needle (detached).

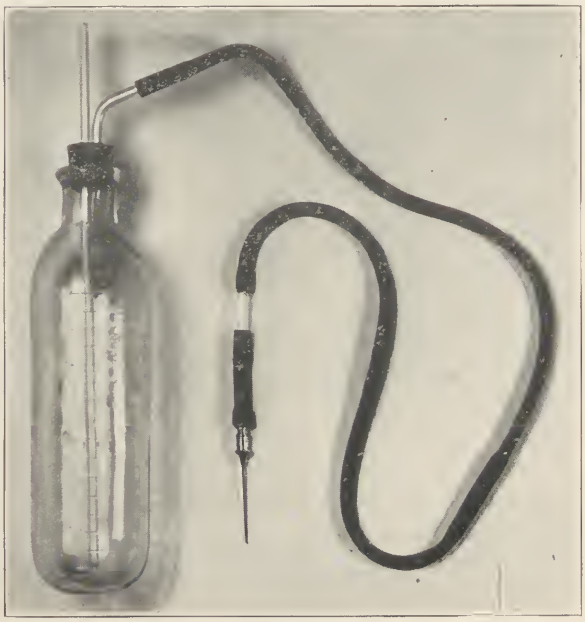

Fig. 70.—Bottle, rubber tubing and needle connected.

(e) One or 2 medicine glasses as containers of the citrate.

(f) One wide mouth flask or jar into which the citrated blood is to be emptied.

(g) One funnel containing several layers of gauze through which the citrated blood is to be filtered from the original flask into the syphon bottle.

(h) One nursing bottle into which the blood is filtered and from which the blood is introduced into the patient's circulation.

This bottle is to be fitted with a tight-fitting, double-perforated rubber stopper into which is introduced 1 straight glass tube and 1 bent tube, the latter being connected with rubber tubing 2 to 3 feet in length, to the end of which is attached a metal tip (Fig. 69). A clamp should be attached to the rubber tubing by which to regulate the flow.

The metal tip must fit snugly into the needle by which the blood is introduced into the body. A special adapter may be used to connect the metal tip with the needle.

Technic.—A Wassermann test should be done on every donor before his blood is used. If the blood is to be introduced intramuscularly or subcutaneously, no blood grouping or matching is necessary nor is sodium citrate necessary to prevent the blood from coagulating. In that case, blood is removed from the donor's vein by venipuncture needle connected to a Luer syringe, a tourniquet being applied an inch or two above the site of the puncture. As soon as the syringe is filled with blood, it is detached from the needle, given to an assistant, who injects the blood into the child's buttocks and meanwhile the operator fills the second syringe with blood. This is repeated until the desired amount of blood is given.

The donor is preferably seated near a table with the arm from which the blood is removed held firmly at the edge of the table.

Needless to say that every precaution is to be taken to keep the field of operation and the blood sterile.

If the blood is to be introduced directly into the child's circulatory system, the blood of the donor and the child should be grouped or matched before the transfusion is undertaken. (Technic of blood matching is described in Chapter IV.)

The blood removed from the donor by venipuncture is filtered into the flask containing the sodium citrate. The blood is then filtered through gauze into the nursing bottle.

Another needle is now introduced into the vein or into the longitudinal sinus of the child. The clamp over the rubber tubing is loosened and the blood allowed to run to the tip in order to expel air bubbles (Fig. 70). The blood is now run in from the inverted nursing bottle into the child's vein or sinus by means of gravity. On completion the site of puncture is sealed by collodion.

CHAPTER XII

INTUBATION, EXTUBATION AND TRACHEOTOMY

If laryngeal diphtheria is recognized early and sufficient antitoxin is given, there is no need of intubation. When the disease has advanced to the stage of cyanosis, retraction of the lower part of the sternum and gasping for breath, the laryngeal obstruction should be relieved by mechanical means. Intubation is preferable to tracheotomy, as it produces no open wound nor does it leave a scar. When intubation fails tracheotomy should be employed.

Two types of intubation instruments are used in America: the O'Dwyer and the Feroud. The first (Fig. 71) is made of hard rubber lined by metal

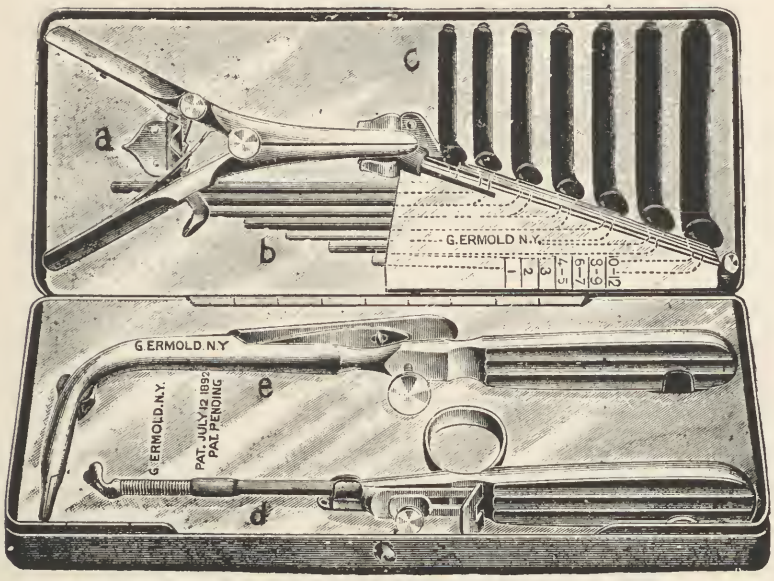

Fig. 71.—O'Dwyer intubation set: *a*, mouth gag; *b*, obturators; *c*, hard rubber tubes; *d*, introducer; *e*, extubator.

and the latter is made entirely of metal. The Feroud is more simple in that no special obturator is used for each tube, and that the same instrument is used both for intubation and extubation (Fig. 72).

INTUBATION

The patient, wrapped in a sheet, to prevent struggling, is placed on a table, the head being brought to the end of the table, and a small pillow placed under the neck to bring the larynx into prominence. The body of the child is held by one assistant and the head is steadied firmly by another assistant. A mouthgag is placed in the child's mouth and held firmly by the assistant holding the child's head. The operator, standing at the right

hand side of the patient, facing him, introduces the index finger of his left hand into the patient's pharynx and pulls the epiglottis toward him, so as to uncover the larynx.

The tube, attached to the end of the introducer held in the right hand and controlled by means of a string stretching from the tube to the hand and wrapped around the finger, is now introduced into the larynx guided by the index finger of the left hand. When the tube is already in the larynx, the introducer is removed and the thread is cut. The mucus in the pharynx is now wiped out by means of gauze and the mouthgag is removed. A "metallic" cough is a good indication that the tube is in the larynx and not in the esophagus. A lessening of the cyanosis and an improvement in breathing is another good indication that the tube is in the larynx.

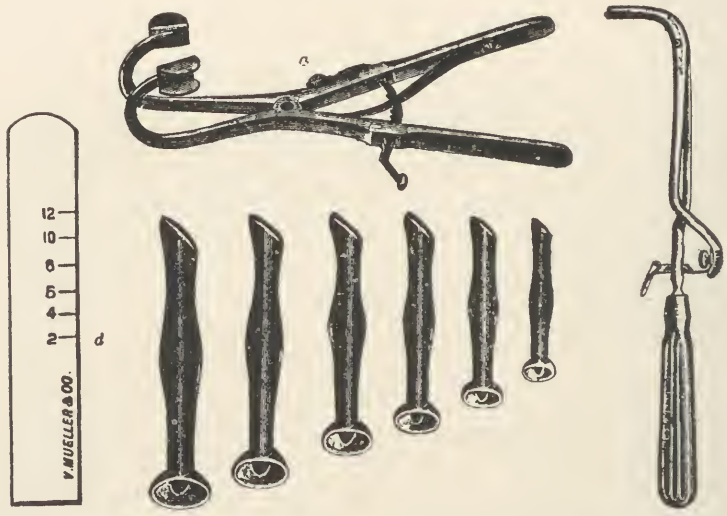

Fig. 72.—Feroud's intubation set: *a*, mouth gag; *b*, introducer and extractor in one piece; *c*, gold plated metal tubes; *d*, scale of years for measuring the sizes of the tubes.

Every intubated patient should be watched constantly by a competent nurse, and a physician experienced in intubation should be at hand, so that in case the tube gets clogged up, the child may be extubated without delay, and if the tube is coughed up and the child becomes cyanotic, reintubation may be performed. For this reason it is always best to treat intubated patients at a hospital for contagious diseases, instead of at home.

Feeding of an intubated patient is best accomplished by the Casselberry method, which consists of lowering the patient's head below the level of the rest of the body while administering food. An intubated patient needs fresh and warm air. A croup kettle may be of some value, but is not always necessary. Ordinary room temperature will usually answer the purpose. Above all it must not be forgotten that all intubated cases must have diphtheria antitoxin to counteract the disease. Intubation serves only as a means of keeping the larynx open for a short while, but does not cure the disease.

The tube, if not coughed up, should be left in the larynx for three days and then removed. If the patient cannot get along without the tube he must be reintubated. If the tube is coughed up before three days, the patient should be watched closely and if he can get along without a tube he should be let alone, otherwise he should be reintubated.

EXTUBATION

Experts often remove the tube by making pressure on the lower part of the larynx. The child then spits the tube out. Some physicians leave the thread in the tube in every intubated case, so as to be able to pull the tube

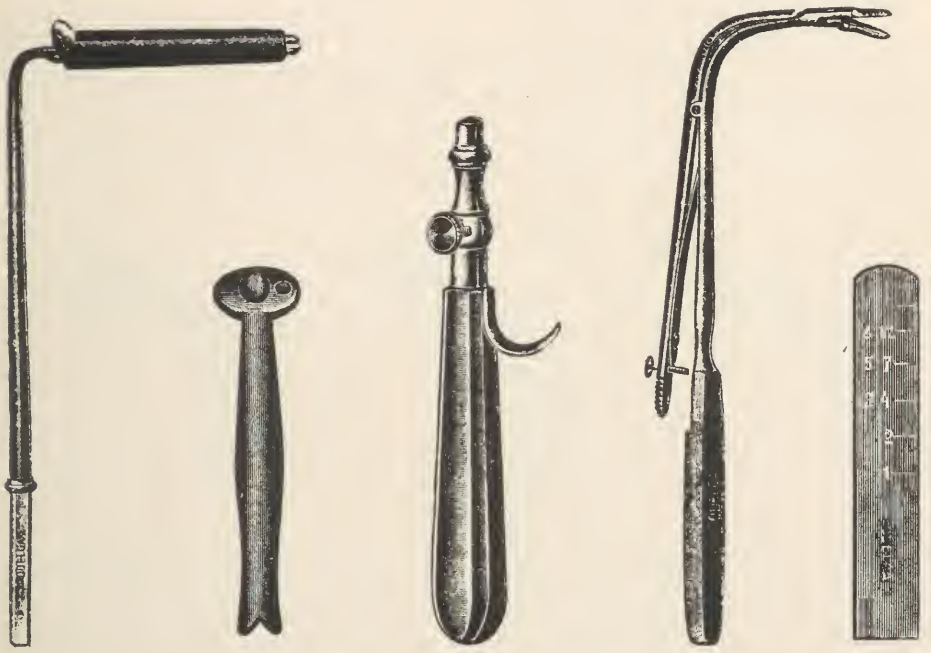

Fig. 73.—Modified O'Dwyer intubation outfit.

out easily. This, however, is not always advisable, as the child may pull the tube out himself. If neither of the above methods is employed, extubation has to be done by means of an extubator. The preparation of the patient is the same as for intubation, and the extubation is performed by pulling the epiglottis toward the operator, introducing the instrument into the tube, and pulling the tube upwards and forwards. An extubated child should be watched carefully, as it may need reintubation very soon.

TRACHEOTOMY

The open laryngeal operation or tracheotomy should be resorted to only after all other means of supplying air to the patient have failed. Such, for instance, may be the case when the obstruction is not only in the larynx but also in the pharynx in which case intubation will do no good. Such may also be the case when there is so much membrane in the larynx that the intubation tube cannot go through at all.

The instruments required for tracheotomy are: (1) tracheotomy tube; (2) scalpel; (3) blunt hooks; (4) needle and catgut or silkworm gut. In time of emergeney one can get along with a tracheotomy tube and scalpel. A pocket knife and the hard rubber or metal tip of a stethoscope have been known to save a life during emergeney.

No anesthetic is required. A loeal anesthetie may be used. A general anesthetic is eounterindicated.

Technic.—The patient is placed in the reeumbent posture with the head at the edge of the table. A sand bag or a rolled towel is plaeed under the neck so as to bring the trachea into prominenee. The patient's head is steadied by an assistant.

After aseertaining the position of the thyroid body and of the erieoid eartilage, an ineision is made through the skin, subcutaneous fascia, and anterior layer of the cervieal fascia. The sternohyoid and sternothyroid muscles are then separated by the blunt end of the scalpel. The isthmus of the thyroid is held downward by a blunt hook. The edges of the wound

Fig. 74.—Tracheotomy tubes.

are also kept separated by hooks. The faseia of the trachea is now cut, exposing the traeheal rings. Two rings of the trachea are now cut with a sealpel held in the right hand, while the traehea is held tense with the left hand. A rush of air and often also of mucus into the wound indicates that the traehea has been cut. The cartilage is now separated and the traeheotomy tube introdueed inward and downward. The tape bands on eaeh side of the tube are tied around the patient's neek so as to hold the tube in position. A sterile pieee of gauze at the base of the tube, next to the wound, helps to keep the dust out. No sutures are neeessary as a rule, but if the wound is large, one or two sutures may be used.

Tracheotomized patients should reeeive extraordinary eare. The inner tube should be removed and eleaned every few hours, or as soon as it elogs up. The gauze around the wound should be changed every day and the outer tube should be removed every two days. The air in the patient's room should be fresh and warm. No eroup kettle, however, is necessary. The tube should be left in four to six days or longer if the patient cannot get along without it.

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